THE
FOUNDRY TRADE JOURNAL
AND PATTERN-MAKER.

Vol. 21. No. 214. OCTOBER 1919. Price SIXPENCE Net.

JOHN MACDONALD & SON, LTD.

ENGINEERS,

WATT STREET, MARYHILL, GLASGOW.

THE BEST TYPE OF MACHINE FOR SHELLS.

"AJAX" STRIPPING PLATE or DIRECT PATTERN DRAW JARRING MOULDING MACHINE.

THE JOLT DOES IT.

OF BRITISH DESIGN and MANUFACTURE THROUGHOUT.

The illustration shows our latest design No. 6 "AJAX" Pneumatic Jar Ram Direct Pattern drawing Moulding Machine. Simplicity and stability are the chief feature of these machines, and they are built to stand the very hardest usage. The size of table is 20in. by 24in. with 18in. pattern draw and lifting Capacity 12cwts. at a working pressure of 80lbs. per square inch. The main Cylinder performs both the jarring and pattern drawing operation, the side rods being adjusted according to the depth of pattern draw necessary. Moulds are successfully rammed in a few seconds, and are thoroughly uniform in density, thus saving at least 10% in overweight of castings. See our M—1 catalogue for further particulars and information regarding other sizes and types of "AJAX" jarring Machines.

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Ferrous and Non-Ferrous.

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This alloy, free from carbon, contains about 80% Tungsten, and is commercially free from all impurities objectionable in steelmaking. Supplied in lumps, and finely crushed, to all leading tool steel makers in the country.

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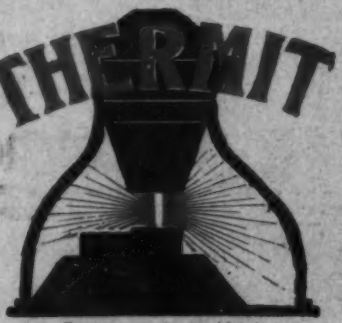

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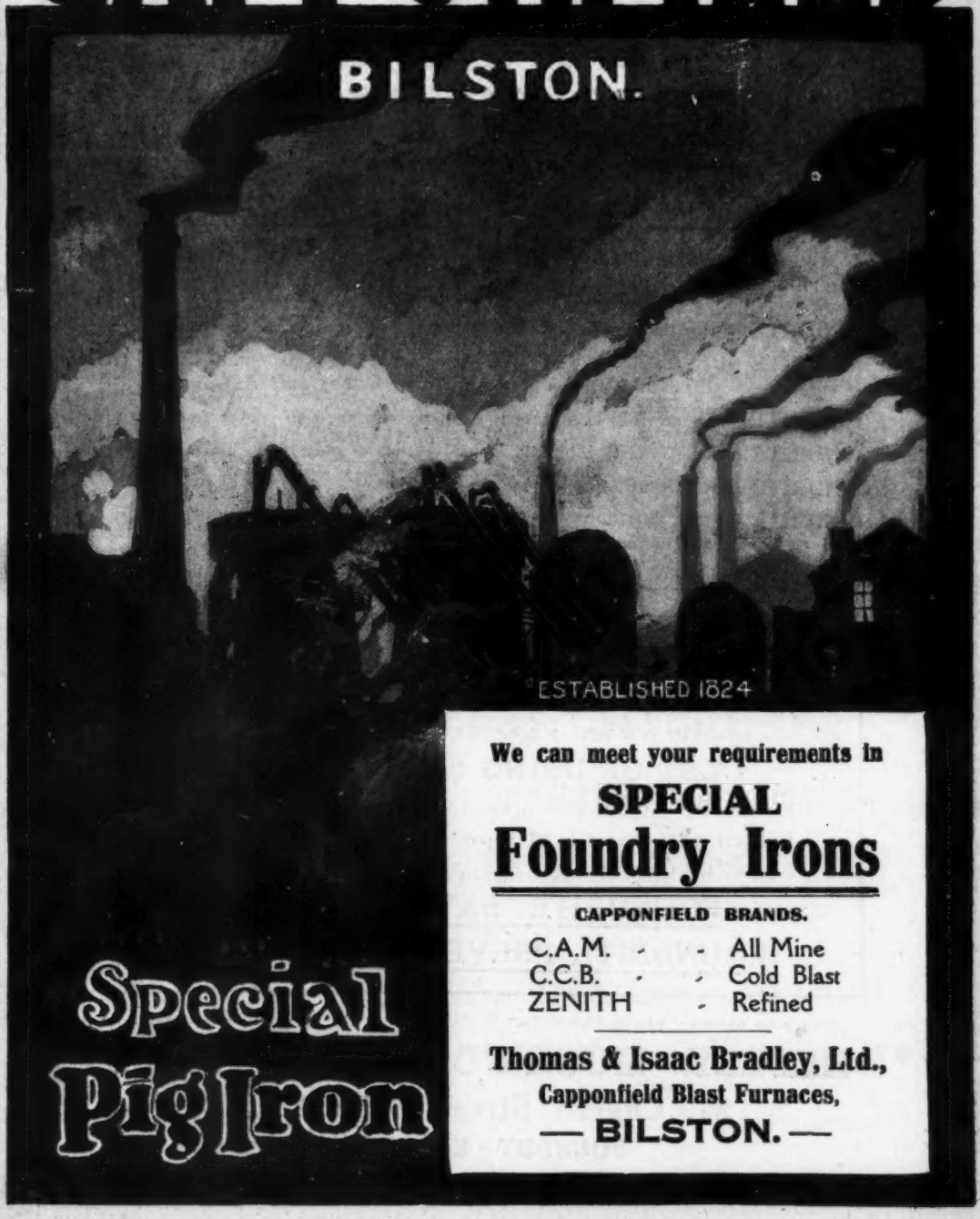

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Foundry Irons

CAPPONFIELD BRANDS.

C.A.M.	All Mine
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Thomas & Isaac Bradley, Ltd.,
Capponfield Blast Furnaces,
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"FOUNDRITE."

"FOUNDRYMEN have been seeking this material for years."

Supplied only in 40 gallon Casks. No bulk broken.

FOUNDRITE *versus* **CORE GUM.**

FOUNDRITE is the binding material for moulding sand and cores.

FOUNDRITE SUPERSEDES and makes unnecessary all classes of **CORE GUM, LINSEED OIL and all other BINDING material.**

FOUNDRITE will renew old and burned sand, making it usable over and over again.

FOUNDRITE makes CORES unbreakable and the use of **core irons** unnecessary.

FOUNDRITE leaves CORES perfectly porous and does **not shrink.**

FOUNDRITE has been **"found right"** for all **Sand binding** in the Foundry **for all purposes.**

FOUNDRITE is supplied in LIQUID form ready for use. Dilute with Water.

The porosity of the core is perfect, and cores so made do not shrink.

No blowing, cracking, crumbling, honeycombing, or loss of strength can take place.

COST OF USING "FOUNDRITE."

For ordinary work the price is about One Penny per gallon.

FOUNDRITE is used in all important Foundries in Great Britain and the Continent.

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"Goldendale"
CYLINDER PIG IRON.

FOR:
STEAM,
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Special Quality for:
AUTOMOBILE AND AERO ENGINES.

UNRIVALLED for Fluidity,
Easy Machining
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DENSE GREY FRACTURE.

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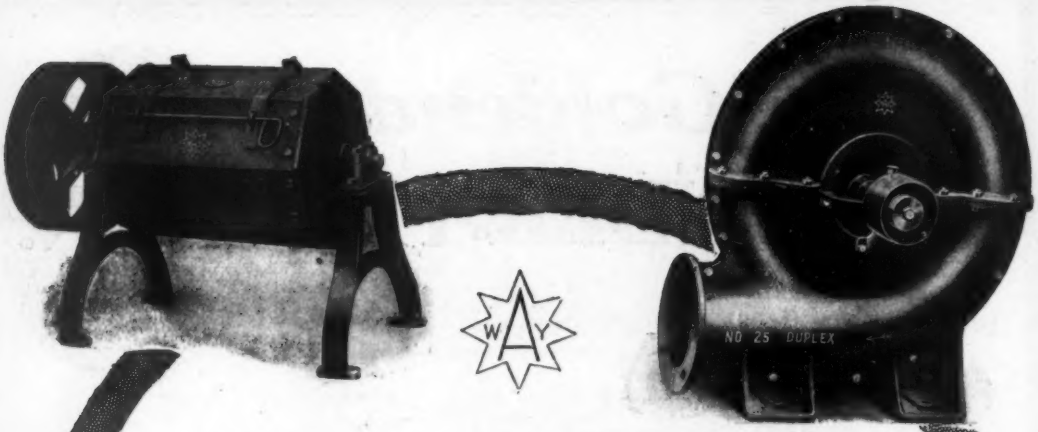

ALLDAYS

FOUNDRY REQUISITES

The accompanying illustrations give but a brief idea of the wide range of Foundry Equipment made by us, which includes:—

BLOWERS, CRANES, CUPOLAS, FANS, MELTING FURNACES (oil, gas and coal fired), LADLES, SAND MIXERS, SMALL TOOLS, Etc., Etc.

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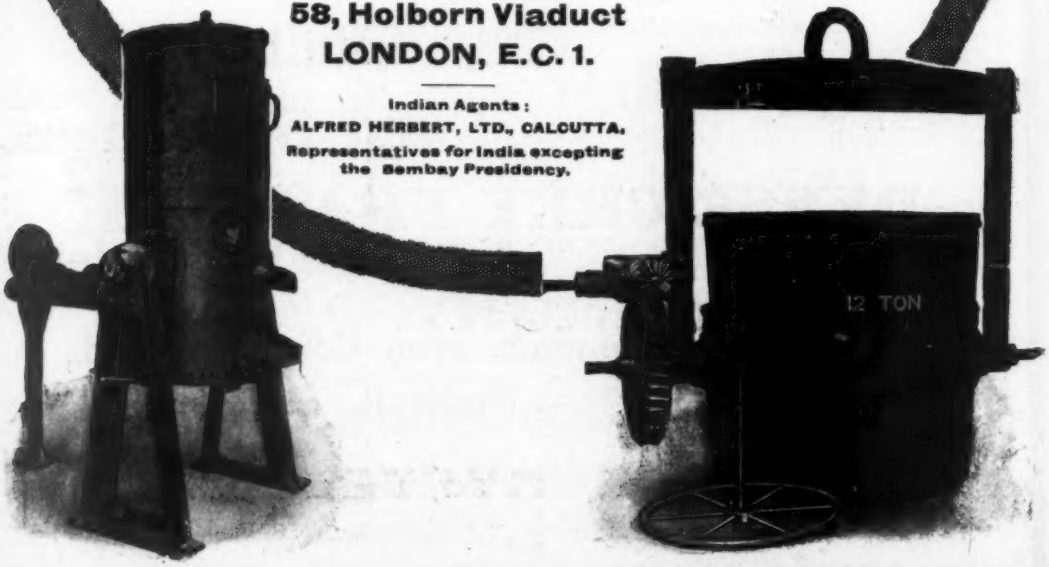

A Noted Otolaryngologist Reported: "At Camp Greenleaf of those claiming to be Otolaryngologists, 70 per cent. were rejected as incompetent."

If this is true of those SPECIALISTS—we wonder what percentage of FOUNDRY SPECIALISTS could pass an examination to obtain a "McLain Diploma"?

One noted foundry specialist (?) advised a foundryman against semi-steel. Of 6000 cylinders the loss was 20 per cent.—

A Loss of 1200 Cylinders!

We advised steel—taught them how to melt it and of the NEXT 6000—only 148 were returned.

McLain's Semi-Steel Turned the Trick.

The pig iron used was high in phosphorus and you know what steel does to phosphorus? If not then let us assume your mixture is 50-50, and the estimated analysis of phosphorus is 1.00 per cent.

For every 5 per cent. Steel added take out 5 per cent. of the 50-50 Mixture and this 5 per cent. Steel will reduce Phosphorus .05 leaving .95 per cent.

10	per cent.	steel—	the	approximate	phosphorus	in	mixture—	.90
15	"	" —	"	"	"	"	"	—.85
20	"	" —	"	"	"	"	"	—.80
25	"	" —	"	"	"	"	"	—.75
30	"	" —	"	"	"	"	"	—.70
35	"	" —	"	"	"	"	"	—.65
40	"	" —	"	"	"	"	"	—.60
45	"	" —	"	"	"	"	"	—.55
50	"	" —	"	"	"	"	"	—.50

We bade goodbye to straight gray iron mixtures LONG AGO—and the above is ONE OF OUR REASONS.

McLAIN GRADUATES

are neither strictly practical nor technical—but a combination of both—which spells EFFICIENCY AND ECONOMICAL FOUNDRY PRACTICE.

McLain's Semi-Steel Turned the Trick and Saved 1052 Cylinders.

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FOUNDRY PLANT.

"Rapid" Cupolas,

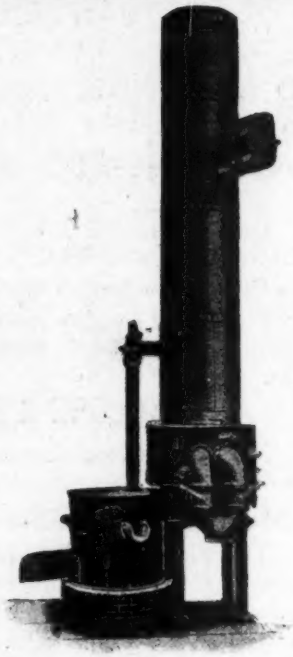
with or without receivers or drop bottoms.

Roots' Blowers,

belt, steam-engine, or electro-motor driven.

Charging Platforms,

Hoists, and Ladles.



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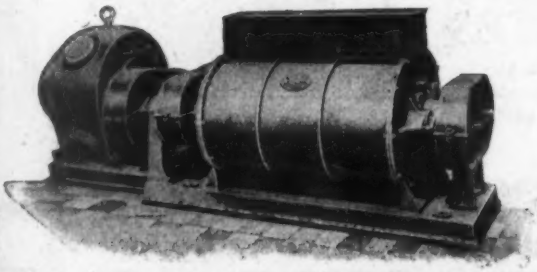
We are also Manufacturers of Steam Hammers, Smiths' Hearths, Centrifugal Pumps and Fans, High-Speed Engines and the "Bradford" Patent Boiler Feed Pump.

We are the original makers of "Rapid" Cupolas as under Stewart's Patent. We make this intimation as other makers are introducing this description, which had become established as a synonym of Stewart's Cupolas.

CONTRACTORS TO HIS MAJESTY'S GOVERNMENT.

THWAITES BROS., LTD.,

Vulcan Ironworks, BRADFORD.



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These Ladles are made with the very finest material on lines that long experience has taught us to know as the most satisfactory.

The Hoffmann Roller Bearings are carefully fitted and fixed in place by screwed plates which keep in the grease but keep out the dirt.

The ladle bodies are made by a special process from a flat steel plate and the trunnions are made solid with the band, which is shrunk on to the bowl.

For prices apply to

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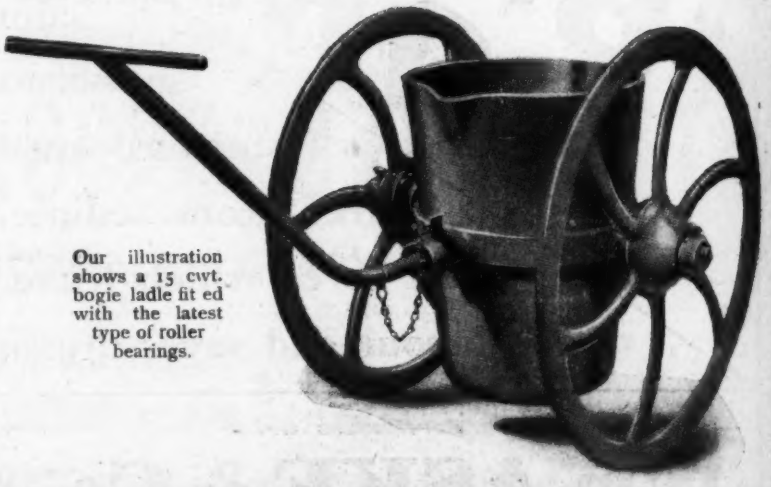
Glasgow.

Telephone: Glasgow Ibrox 820, 1, 2 and 3.
Telegrams: "McNeil, Glasgow."



Our illustration shows a 15 cwt. bogie ladle fit ed with the latest type of roller bearings.

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YOU ought to use "Baltiseed" Core Oil. During the War, and for many years before, it has been the means of a tremendously increased output for those who have, and is admitted to be the Best Core Oil ever produced for Iron and Steel Castings.

"BALTISEED" (REGD.) CORE OIL.

It is a scientifically prepared compound, simple in use, and a guaranteed standard quality, absolutely free from sediment, makes perfect cores, which leave castings without labour and saves dressing room costs.

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SUPER EFFICIENCY !

If you wish to be successful in the manufacture of high grade castings it is essential that you use

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for your CORES, which being the highest grade COMPOUND will overcome all difficulties.

THE ORIGINAL, THE BEST.

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SPECIAL COLD BLAST PIG IRONS.

Brands:

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D.M.R. CHARCOAL FOR MALLEABLE CASTINGS, &c.

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ALL MINE.	WARM BLAST.	COLD BLAST.
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☛ IF YOU HAVE DIFFICULTIES WITH YOUR SPECIAL CASTINGS CONSULT US.
We can put you right.

WILLIAM CUMMING & CO., LTD.,

FOR
IRONFOUNDERS'
BLACKING
PLUMBAGO
BLACK LEAD
OORE GUM
COAL DUST
ETC.

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Write for Quotations.

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Established 1840.

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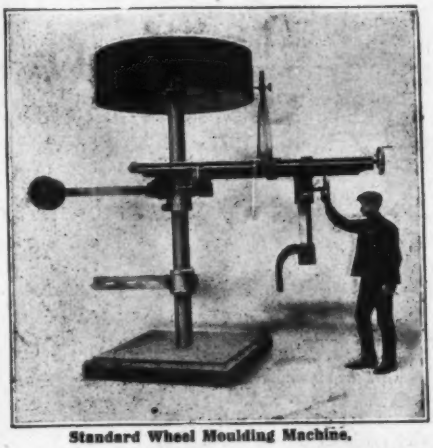


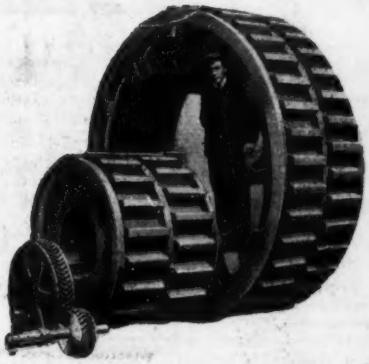
Standard Wheel Moulding Machine.

ALL IRON AND STEEL FOUNDRIES

SHOULD BE EQUIPPED WITH

STEWART WHEEL MOULDING MACHINES.

Complete Satisfaction Guaranteed



Wheels Moulded by this Machine.

No Loose Parts Liable to be Lost.

ACCURATE. PORTABLE. CHEAP.

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IRON CEMENT "A" A D "B" FOR FOUNDRY USE.
FLUX IRON AND GUN, BRASS, BRONZE, ETC.
CASTING SAND IRON AND BRASS.

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The tools illustrated and described in our catalogue—a copy of which we will gladly send you—reveal a standard of efficiency which will meet, we claim, more accurately than any others, the present day demands of all progressive firms engaged in the Engineering and Kindred Industries.

May we send you a copy of this book?

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OF ALL KINDS

COAL DUST, CHARCOAL, PLUMBAGO and BLACK-LEAD CORE GUMS and all Foundry Requisites, and have done so since 1831.

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New Standard Unit

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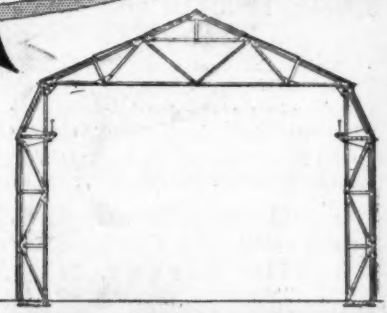

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SILICO-MANGANESE { **23/30** % Silicon. **65/70** % Manganese and **1** %, **2** %, **3** %, Carbon Maximum.

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ALUMINIUM **98/99** % Purity. *In Notched Bars and Half Round Sticks and Granular.*

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STRAW ROPES

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We make STRAW ROPES in sizes of 1¼", 1", ¾", and ½" diameter.

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Foundry Specialists & Wire Brush Manufacturers,

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Of every description.

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FIRE BRICKS & CLAY

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Best Quality.

LESSEES OF DELPH AND TINTERN ABBEY BLACK AND WHITE CLAY.

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THE "PORTWAY"

PORTABLE CORE OVENS

For Gas or Fuel.

TESTIMONIAL.

From The Braintree Castings Co.,
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Gentlemen,

We are very pleased with the Core Oven we recently purchased from you. We find it dries the cores quickly without burning them. It is very handy and economical to use and is altogether superior to other ovens of this type we have in use.

Will you please quote us your best price for four more like it,

Yours faithfully,
For The Braintree Castings Co.,
(Signed) W. B. LAKE, Director.

Makers: **C. PORTWAY & SON,** TORTOISE STOVE & PORTWAY PORTABLE OVEN WORKS, **HALSTEAD, ESSEX.**

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YORKSHIRE STEEL MOULDING SAND,
in regular use in many of the largest Steel Foundries in the country.

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SILICA BRICKS. Special Grade "E" for Electric Furnaces.
REFRACTORY HOLLOW-WARE.

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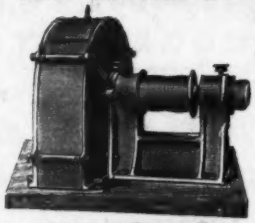

18" *Mixer—1 Ton per Hour.*

Fitted with Patent Roller Bearings, Renewable Reels, Grinds, Mixes, Screens & Prepares.

OLD AND NEW FOUNDRY SANDS AT LOWEST COST.

Saves Labour—Reduces Foundry Costs.

Made in Three Sizes—1, 3 and 6 Tons per hour capacity.

USED IN PRINCIPAL FOUNDRIES.

PRICES ON APPLICATION.

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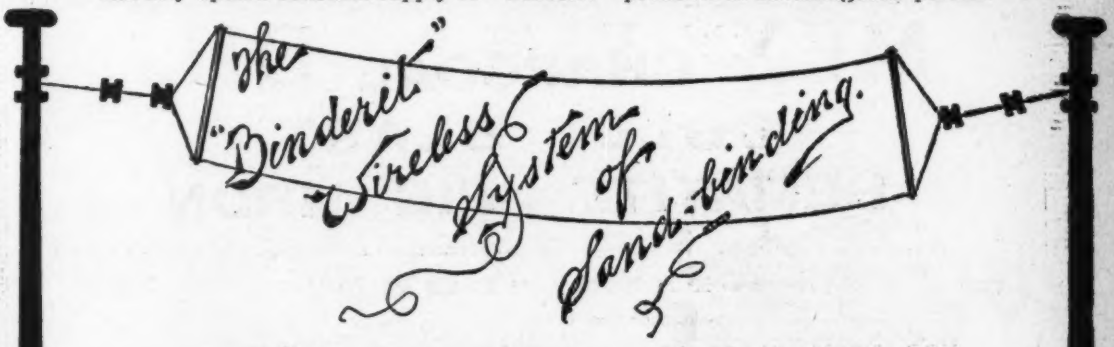

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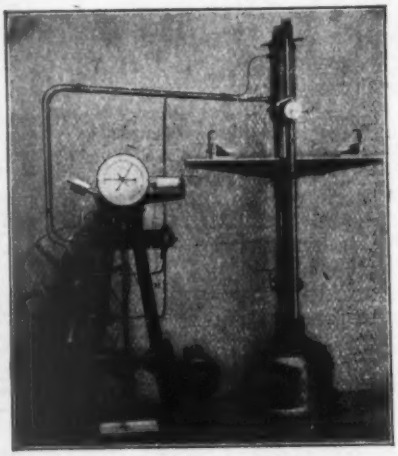

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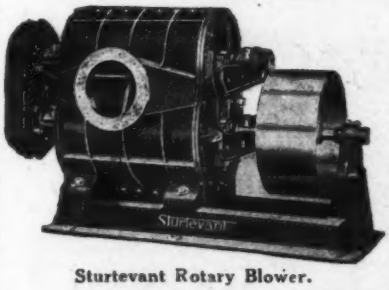

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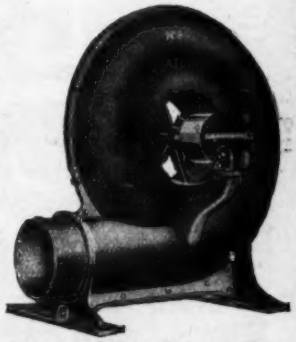

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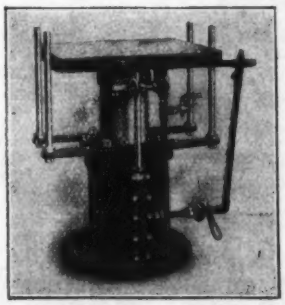

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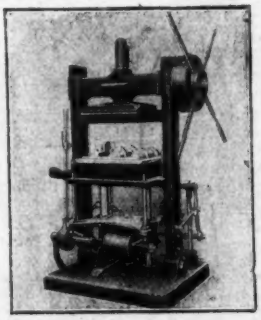

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The Foundry Trade Journal

AND PATTERN MAKER.

THE OFFICIAL ORGAN OF THE INSTITUTION OF BRITISH FOUNDRYMEN.

Vol. 21. OCTOBER, 1919. No. 214.

PUBLISHED THE FIRST WEEK IN EACH MONTH

Subscription Terms: 7s. 6d. per annum, post free.

To place the "Journal" within the reach of working Moulders and Pattern-makers, the Proprietors will accept subscriptions, not less than three in number from one shop, at the reduced rate of 5s. per annum, such order to be countersigned by the superintendent or foreman.

All communications to be addressed to the Editor, or to the Publisher, as the case may be, of

The Foundry Trade Journal,
Bessemer House, Adelphi, London, W.C.2.

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Forthcoming Events.

OCTOBER 8.

Birmingham Metallurgical Society:—Visit to the Haywood Forge, Halesowen.

OCTOBER 20-23.

International Electrotechnical Commission:—Plenary meeting.

OCTOBER 31.

Institute of Marine Engineers:—Annual dinner.

NOTES AND COMMENTS.

The Iron and Steel Industry and Protection.

With the removal of restriction on imports as from September 1, we are once again on a free-trade basis, for except in the case of certain key industries there is now freedom to import manufactured material freely into this country. The list of key industries as announced by the Board of Trade seems to have been narrowed very considerably when we recollect our experiences during war time, and the feverish haste and great cost at which these deficiencies were overcome. The principal "key" products, as defined by the Board of Trade and of interest to the engineering trades, are scientific glass ware, porcelains and instruments, ferro-tungsten, magnetos and gauges. No doubt many who have been induced by the specious promises of the Government to build works to carry on German monopolies during the war will find themselves in a very difficult position, because although in normal times they might be able to meet German competition, the drop in the exchange value of the mark means an immense stimulus to German exports. So far as iron and steel are concerned the after-the-war position is that the steel-makers want the free import of pig-iron, and the re-rollers want free imports of steel. The steel-makers have to face the fact that the increased steel capacity is four million tons, and the increased pig-iron capacity is less than one million tons, and this figure may indeed be even smaller when allowance is made for furnaces which will probably never be re-lighted. On the other hand, in 1913 we exported one million tons of foundry and forge pig-iron, and possibly some of this capacity may be permanently used for steel-making irons. Making all due allowance, however, the conclusion is irresistibly reached that it is not possible to produce an output of twelve million tons of steel, because with the insufficient production of pig-iron the raw materials are not available, and this in spite of the fact that an average of 50 per cent. of scrap is used in the furnace to-day as against an average of 30 per cent. before the war. For this reason many of the steel-makers wish to have a free hand to import pig-iron rather than to raise more raw materials and put up additional blast furnaces.

Electric Lifting Magnets for Steelworks and Foundries.

We have recently received from The Witton-Kramer Electric Tool & Hoist Works an interesting publication dealing with their electric lifting magnets, in which they say that during the last ten years very considerable progress has been made in the manufacture and application of lifting magnets for industrial service. Almost every steel works and large foundry has adopted these appliances for handling both raw material and finished products, the saving in time and labour effected being so great that in many instances the installation of special high-speed cranes for use

with the magnets has been justified, the initial outlay of both crane and magnet being recovered in a very short time. An instance may be cited in which a 52-in. magnet, operating in a steel works, effects a saving of approximately £1,500 per annum. For handling iron and steel in bulk, lifting magnets obviate the necessity of using slings or chains to attach the load to the crane hook. It is impossible to handle economically rough material such as pig-iron, scrap iron, billets, crop ends, ingots, turnings, borings and the like by hand labour, nor can metal of this description be slung efficiently from a crane hook. With a magnet the whole operation can be carried out by the crane driver, in many cases even without the assistance of ground men. It is also possible with a lifting magnet to stack metal to a much greater height than is possible by hand, resulting in a considerable saving in floor space. Further, material can be handled at high temperatures, the magnetism of steel being unaffected at temperatures up to and a little over 700 degs. C.

Hardware Exhibition in Brazil.

The great extent to which American iron, engineering, and hardware manufacturers and exporters have taken advantage of the opportunities afforded them in Brazil by the war may be judged by the Brazilian trade returns, which show that although German competition has been practically destroyed, British manufacturers are now faced with still more serious competition from one of the most highly developed manufacturing countries in the world. The seriousness of the situation has been the subject of a good deal of study on the part of the officers and members of the British Chamber of Commerce of Sao Paulo and Southern Brazil, and among the projects which they have put into execution with the object of influencing Brazilian importers to purchase British goods has been the making of arrangements to hold a series of British industrial exhibitions in the City of Sao Paulo, which is the heart of the great manufacturing district of Brazil, and, indeed, of South America. From December 1, 1919, to February 28, 1920, the first of these exhibitions will comprise small hardware goods and other lines allied to the hardware trade, and invitations to participate are now being sent out to United Kingdom manufacturers of these goods. Manufacturers who have not received invitations direct from the Chamber to take part in these exhibitions may obtain full particulars and the necessary applications for space forms either from the Department of Overseas Trade, London, or from Mr. Tom Johnson (the Chamber's Representative), 6, Tokenhouse Yard, London, E.C. The address of the Chamber in Sao Paulo is Rua 15 de Novembro, 20.

The British Iron Manufacturers' Research Association.

This company, limited by guarantee, without share capital, was registered on September 6. The company was not formed for the purpose of profit, and the word "Limited" is omitted from the title by licence of the Board of Trade. The objects are to promote research and other scientific work in connection with the manufacture of malleable wrought iron, and the extraction, preparation, or adoption for use of all by-products arising therefrom. Only iron manufacturers whose principal works are in the United Kingdom are eligible for membership, although the Board has discretionary powers in this connection, subject to confirmation at a general meeting. Members must be British subjects or British corporations. The management is vested in a board of not less than five nor more than twenty members, the following districts being represented, viz.: (1) Lancashire; (2) N.E. Coast of England; (3) Scotland; (4) Staffordshire, Salop, Worcestershire, and Warwickshire; (5) Yorkshire (except the parts comprised in N.E. Coast district) and Derbyshire. The first members of the Board are A. B. Baylis (Midland Iron Company, Limited, Rotherham), J. J. Bleckly (Pearson & Knowles Coal and Iron Company, Limited, Warrington). J. B. Harding (Robert Heath & Sons, Limited, Stoke-on-Trent), H. Martin (Wm. Martin, Sons & Company, Coatbridge), G. Raine (Raine & Company, Limited, Newcastle-on-Tyne), J. S. Trinham (N. Hingley & Sons, Limited, Dudley), and W. Wylie (Scottish Iron and Steel Company, Limited, Glasgow). The registered office is at Atlantic Chambers, Brazenose Street, Manchester.

Institution of British Foundrymen.

The Birmingham Branch of the Institution of British Foundrymen is this year trying the experiment of holding mid-week meetings instead of at week ends, as heretofore. By this means it is hoped to increase the popularity of the Institution and its work. The meetings are to be held at the Chamber of Commerce, Lew Street, Birmingham. The programme is as follows:—October 9, 1919: Presidential address, Mr. H. L. Reason. October 20: Visit to Messrs. Austin Motor Company, Limited. November 15: Paper by Mr. A. R. Bartlett, "The Core Floor and its Essentials." December 11: Paper by A. Harley, Coventry Branch President, "Science and Foundry Work." January 10, 1920: Paper by J. Robinson, Halifax, "Core Stoves and Mould Drying." January 17: Annual dinner. February 12: Paper by Prof. C. A. Edwards, D.Sc., Manchester University. February 18: Visit to Coventry. March 11: Paper by H. R. Shackleton, Keighley, "Methods of Moulding Patterns for Plate and Machine Work." April 8: Annual general meeting, followed by paper by J. E. Hurst, Manchester, "Permanent Moulds and Centrifugal Castings."

Zirconium in Steel.

According to a recent issue of "Le Génie Civil," zirconium and its alloys, added to molten steel, dissolve completely. The ferro-zirconiums thus obtained possess an unusual degree of strength which has made them useful for the manufacture of armour or any form of sheet metal for defensive purposes. Armour made of nickel-zirconium steel, having a thickness of 10 mm. (0.39 in.) has shown the same resistance to the bullet as nickel-molybdenum steel of 13 mm. (0.51 in.) thickness or chronium steels of 16 mm. (0.63 in.) thickness. The zirconium steel which has given the best results has the following composition:—Carbon, 0.42; manganese, 1.00; silicon, 1.50; nickel, 3.00; zirconium, 0.34 per cent. Its physical properties are:—Tensile strength, 125.73 tons per sq. in.; elastic limit, 107.31 tons per sq. in.; Brinell hardness, 470 (weight of ball 10 kg., impression 2.8 mm.).

REPAIRING STERNFRAME.—The Metal and Thermit Corporation, New York, it is reported, has recently completed the largest marine weld ever recorded, on the cast steel sternframe of the United States army transport "Northern Pacific." The section welded was entirely broken through as a result of the severe strain to which the frame was subjected when this transport, laden with homeward-bound troops, ran aground on January 2, 1919, in a fog off Fire Island, New York. The sternframe was broken just above the upper rudder lug, in a position where the casting is hollow, and measures almost 2 ft. in diameter. The walls of the casting at this point are about 3 in. thick. The weld which required 1,400 lbs. of thermit for the chemical production of the necessary amount of molten steel, and which was made without removing the casting from the ship, obviated the delay and expense which would have been entailed by the alternative of purchasing a new casting and installing it. In preparing the mould for the weld, 40 barrels of backing material and six barrels of facing sand were used. The metal was preheated for seven hours prior to the reaction.

Electric Furnaces.*

By J. H. Stansbie, B.Sc., F.I.C.

In some general preliminary remarks Mr. Stansbie pointed out that the cheapest source of electric current was kinetic energy of falling water, and on this account the principal developments in electric furnace work had taken place in districts where water-power was abundant. At the same time, the superiority of the electric furnace over coal- or gas-fired furnaces for some purposes had made its introduction necessary in districts where the cheaper forms of power could not be obtained. Mechanical energy was converted into electric energy either by the direct-current dynamo or the alternator. In principle the alternator consisted of a coil of insulated copper wire moving rapidly in a fixed magnetic field, or a moving magnetic field embracing a series of fixed coils in its motion. In either case alternating currents were set up in the coils, which were so arranged that they filled and emptied on the lines of force, passing through the magnetic field twice and in opposite directions during a complete revolution of the machine. The current in one direction increased in strength from zero to a maximum and then decreased to zero. This was followed by another current in the opposite direction, which also increased from zero to a maximum and decreased again to zero. These alternating currents followed each other rapidly, and could be passed through outside conductors in which the same alternations took place.

The speaker dealt in some detail with the construction of electric generating machines, describing the difference between single-phase currents and poly-phase currents. By the use of one-, two-, and three-phase currents the moving energy of a piston-rod or turbine was converted into electric energy with very little loss. In the best practice the machine was coupled direct to the prime mover. The energy of the current was converted into heat by introducing a resistance into its path, and if no other work was to be done the whole was so converted. Joule found that a current of 1 ampere flowing for one second through a resistance of 1 ohm developed 0.24 calories of heat. One Watt-second would develop sufficient heat to raise 3.7 grains of water through 1 deg. C. Joule also proved that the heat required to raise 1 lb. of water through 1 deg. C., if expended in work, would raise 1,390 lbs. through a vertical height of 1 ft. That was the mechanical equivalent of heat. Watt estimated that a horse working for one second would raise 150 lbs. through a vertical height of 1 ft. Therefore 1 h.p. working for one second would develop enough heat to raise $\frac{550}{1390} = 0.395$ lbs. = 2,765 grains of water through 1 deg. C. Therefore 1 h.p. $= \frac{2765}{3.7}$ = 746 watts. That established the relation between mechanical and electrical energy. The watt-second was much too small for a practical unit, so the kilowatt hour, the Board of Trade unit, was in common use. Whether steam, gas, oil, or water power was used as prime mover depended on surrounding conditions. The chemical energy of carbonaceous fuel, if it could be completely converted into electric energy, would be equal to 0.005d. per kw.-hour., but under the best conditions obtainable to-day only about 15 per cent. was utilised. There was, therefore, a very wide opening for improvement in the conversion of the latent energy of fuel into electric energy.

The best results of water-power installation gave 0.05d. per kw.-hour, while for gas engines it was about 0.3d. per kw.-hour. There was no doubt that the cheapest source of electric energy in this country was that of blast-furnace gas burnt in the cylinders of gas engines. The absorption of energy in an electric furnace may be very great; thus a furnace 16 ft. square could absorb 12,000 h.p., so that the price of energy is an important item in electric furnace working.

The important property of electric energy is its power of concentration so that it can be obtained in great density. This means that when it is rapidly converted into heat a very high temperature can be obtained. The maximum sustained temperature generated by combustion is determined by the dissociation temperature of the most stable product of the chemical change by which the heat is generated, and this does not much exceed 2,000 deg. C. In the case of the electric arc the temperature is limited by the volatilisation of carbon, and is not less than 3,500 deg. C. Carbon is the only known substance which remains solid at this temperature. It is possible that higher temperatures may be developed for a short time by both means. Thus Moissan concentrated the energy of some 270 h.p. in a lime cavity 4 in. in diameter, with the result that the lime flowed like water and rapidly volatilised, and this investigator was of opinion that the temperature is a function of the current density; but it is evident that in this case the temperature was limited by the volatilisation of the walls of the lime cavity.

Excessively high temperatures are not required for ordinary metallurgical operations, although they are very interesting from the scientific point of view. Moissan and others have succeeded in producing artificial gems, and among them the diamond.

Coming now to the question of electric furnaces, the author pointed out that the principle of any furnace in which heating effect only is required must depend upon the heat developed by resistance of solid, liquid, or gaseous conductors; but as this resistance may be offered in different ways there are several types of furnace in use, classed as (1) arc, (2) resistance, (3) induction. There are also combinations of these types, such as Arc-resistance and Induction-resistance. The adaptation of the electric arc to the investigation of metallurgical problems orginated in the early years of the last century, Sir H. Davy working with it more than a hundred years ago.

The ideal furnace is very simple in construction, the terminals of the generator being connected with carbon rods of sufficient diameter to carry the current. Gearing is connected to one of the rods, by which it may be made to touch the other, or conducting material, in contact with it. The current passes, and if the voltage is more than 40 volts for direct current, or 30 volts for alternating currents, an arc will form separating the two. The gap is filled with carbon vapour resulting from the high temperature developed in the gap. If the arc is enclosed so that a conducting

* Read before the Birmingham Branch of the Institution of British Foundrymen March 22, 1919, Mr. J. J. Howell in the chair.

vapour may accumulate in the space the length of the arc may be extended to several feet. The cavity under the carbons represents the bed of the furnace upon which operations may be conducted. The larger number of furnaces are of the arc type, in a more or less modified form, the first of which was devised by Siemens, who patented a crucible furnace for steel melting in 1875.

The author next proceeded to describe various types of electric furnaces.

The Stassano Furnace (1898).—In the latest form of this furnace the heating chamber consists of a circular steel shell surmounted by a dome roof and lined with a refractory brickwork. The carbon electrodes are passed through holes in the sides and kept cool on the outside by water-jackets. Tap-holes for slag and metal are provided, together with an opening fitted with a shoot for the introduction of the charge. The furnace is mounted on an axis slightly inclined to the vertical, on which it can be rotated by gearing. The electrodes are connected to metal insulated rings on the axis, through which the current passes from the generator by rubbing contact when the arc is made. The arc, which is comparatively short at first, can be extended as the chamber fills with conducting vapour. The charge is heated by direct radiation from the arc itself and by secondary radiation from the walls of the chamber.

A furnace 3 ft. by 3 ft. will absorb the energy from alternating current of 2,000 amps. at a pressure of 170 volts, which is equal to 450 h.p. The furnace was originally designed for the reduction of iron ore, but under the most favourable conditions of ore supply was unable to compete with the blast-furnace. Count Stassano then used it for the manufacture of steel from turnings and other scrap at the Royal Artillery Works, Turin. Afterwards furnaces absorbing up to 1,000 h.p. and using three-phase current were installed. In this case three electrodes are inserted to take the different phases. Furnaces of this type have been adopted in the U.S.A. for making high-grade steel. They have a capacity of 1 to 1½ tons and are worked with three-phase current. Very good results are said to be obtained from them.

The Rennerfelt Furnace, which is a development of the Stessano, is a two-phase furnace with three electrodes. Two of these are horizontal and the third vertical. The result of this arrangement is that a magnetic field is generated in the neighbourhood of a third electrode, which causes the arc to be deflected downwards on to the top of the bath and gives better heating effects. The two phases are connected to the horizontal electrodes, and the common return to the vertical electrode

The Heroult Furnace (1901).—This furnace and its modifications are among the most successful for steel manufacture. It consists of an iron shell, lined with refractory materials, the roof with silica bricks, and the working bed with acid or basic material. The bed in most furnaces is basic, and is formed of either magnesite or dolomite. The electrodes are passed through the roof, and are surrrounded on the outside by copper cooling chambers to keep down the temperature of the exposed parts. The ironwork of the shell is not continuous, but is separated in parts by copper strips so as to prevent the formation of a continuous magnetic current, by which energy losses would be incurred. There is a working door at one end and an outlet for gases in the roof. The tapping spout is in the front of the furnace, and the whole structure is supported on gearing, by which it can be tilted for pouring. The carbons are held in grips, which can be raised or lowered by hand gearing or by a small motor attached to the standard.

In working the furnace considerable fluctuation in the values of the current may take place, so that in good practice it is necessary to have means of automatically regulating the position of the carbons with respect to the charge. The "Thury regulator" is largely used for this purpose. It consists of an electro-magnetic balance, which is in equilibrium as long as the current and pressure remain normal, but on any variation of these conditions the balance either raises or lowers a lever, which allows current to enter the motor in one direction or the other to raise or lower the carbon. This continues until the conditions are again normal and the balance is restored. Most of the heat is derived from the arcs which are formed between the carbons and the surface of the charge, and the temperature may be regulated by varying the distance through which the arcs strike.

The furnace is commonly used for melting and refining in steel manufacture. If pig-iron is one of the constituents of the charge the melting is unsatisfactory, as there are sure to be large fluctuations in the load from short-circuiting. It is best to run the pig metal into the furnace in the molten state, and is the most economical when the furnace is used in conjunction with a "mixer." The scrap is then added and the charge fully melted. A basic slag is formed to carry on the refining. The silicon, manganese, phosphorus, sulphur, and carbon are oxidised and pass from the metal into the slag. It is well known that the changes in the composition of the metal and slag are brought about by the reactions which take place between the upper surface of the metal and the under surface of the slag, and that these changes depend to a considerable extent upon the temperature of metal and slag. Superheating plays an important part, and it is quite possible to have temperature conditions such that impurities pass from the slag into the metal instead of from the metal to the slag.

The chief advantage of electric refining is the ease with which the temperature can be regulated and an impure slag replaced by a purer one, thus enabling the refining to be carried to any desired limit. Further, a reducing slag may be formed of lime, silica, fluor spar, and ground coal, by which the sulphur content can be brought to a lower limit than is usual in open-hearth working or crucible melting; also, the higher temperature at which the metal can be tapped from the ladle into the moulds facilitates the escape of gases and promotes soundness in the ingots. The readiness with which an oxidising, reducing, or neutral atmosphere may be maintained in the furnace is also in its favour. This is largely due to the fact that the furnace may be closed so as to exclude outside gases.

The principal modifications are the "Girod," the "Greaves-Etchells," and the "Electric-Metals."

One of the faults of the Heroult furnace is that the greater part of the heat is developed in the immediate neighbourhood of the arcs, so that an exceedingly high temperature is obtained in the part of the slag directly under the carbon electrodes, while other parts of the slag and the metal itself are underheated—the heat is not uniformly distributed.

The Girod Furnace.—A fairly successful method of more evenly distributing the heat is employed in this furnace. Several iron electrodes are inserted in the bed, principally towards its circumference, with their upper ends flush with the surface and their lower ends connected with a water-cooled iron box. Thus, if the furnace is worked with three-phase current, two phases are connected with the carbon electrodes passing through the roof, and the third phase with the iron box. Good-quality iron is used for the electrodes, so that the charge may not be contaminated. The current therefore flows to and fro between the upper and and lower electrodes through the arcs and the bath. A violent motion set up during the conversion of electric energy into heat, brings the particles of the metal into rapid contact with the slag and hastens the refining. Currents moving in the same direction attract each other, and conductors carrying them tend to come together. This tendency increases with the current density (amperes per square inch of cross section), and is known as the the "pinch" effect. A column of molten metal may be regarded as a bundle of movable conductors through which the currents are passing in the same direction, so that the pinch effect is active, and if the column is contracted an upward flow, followed by a corresponding downward flow, will take place, with consequent mixing of the metal. Attention was first called to this effect in 1909 by Carl Hering, who designed and patented a furnace upon this principle.

The Hering "Pinch" Furnace.—The idea in this furnace is to use the liquid resistance of the bath of metal for the generation of heat, and to dispense entirely with carbon electrodes. The pinch effect is obtained by forming in the bed of the furnace two or more inclined channels of circular section. These are lined with magnesite and closed at the bottom by water-cooled metal electrodes. With three-phase current there would be three electrodes connected with the leads from the transformer. To start the furnace it is necessary to run in molten metal in sufficient quantity to fill the channels and connect them electrically. When the current is switched on, heat is generated by the resistance of the metal in the channels and baths and the pinch effect commences. The metal in the channels tends to move towards the centre and upwards, while metal from the bath flows down the sides. Thus currents are set up and the heat generated is distributed. In the case of steel refining, the remainder of the charge is added and a slag blanket formed. The surface of the bath is lifted up over the resistor channels and has the appearance of boiling. This is caused by the very hot metal from the channels being forced upwards against the slag blanket, and it is claimed that the conditions thus obtained are the best for rapid refining. With excess of lime and fluorspar in the slag, it is also claimed that the sulphur content can be brought very low. The furnace can also be used for melting brass and other non-ferrous alloys, and will probably be more useful for that purpose than for steel refining. The electrodes should be of similar metal to that under treatment.

The Greaves-Etchells Furnace.—In this furnace the bottom lining is so modified as to give a much better distribution of the heat. The working bed is made up of materials which are either conductors when [illegible] become so when heated to a sufficient tem[illegible]. Such a bed may be formed by a laye[illegible]se carbon in contact with the iron shell, followed by a course of magnesite bricks, upon which the working bed of dolomite lime is rammed. In working the furnace a three-phase current is used. Two of the phases are connected to the two carbon electrodes passing through the roof, while the third phase is connected with the bottom of the shell. In such a case the charge is uniformly heated and a rapid motion of the particles set up, by which all parts of the metal are brought into contact with the refining slag. In this way very effective and rapid refining takes place.

Further, a very useful modification in the tilting mechanism is introduced in this furnace, which is so arranged that the pouring spout moves up and down in a vertical line instead of through the segment of a circle, as is usually the case. This allows of the ladle being kept in one position during pouring.

The success of the Greaves-Etchells furnace seems to be assured, as no fewer than 60, varying from half a ton to 10 tons capacity, have been installed in various parts of the world.

Electro-Metals Furnace.—The carbon electrodes pass through the roof of the furnace, and their position can be regulated by means of gearing. The bed consists of conducting material similar to that of the Greaves-Etchells. The furnace is constructed to use two-phase current, the two outer leads being connected to the carbon electrodes, and the neutral lead to the bottom of the bed which forms the fixed electrode. The supply current is usually three-phase, and has to be converted into two-phase by a system of transformers. The makers, in view of a more uniform distribution of heat in larger furnaces, have devised a system by which the ordinary three-phase high-tension current can be transformed into four-phase current so that four carbon electrodes may be used. In this case the neutral lead will also be connected with the furnace bottom. A number of these furnaces are in use and are working successfully.

The Electro-Bessemer.—An example of a combination furnace was described by V. O. Cutts in 1910 under the name of the Electro-Bessemer. This furnace is designed to reduce the cost of electric energy by making preliminary refining of pig metal by a blast of air as in ordinary Bessemer working. In this way the silicon, carbon, and phosphorus are largely removed, and the metal is then transferred to a second chamber in the apparatus, fitted with carbon electrodes, to finish the refining. The second chamber is heated by the hot gases generated during the blow. The first slag is run off and a purer slag formed to finish the refining by electric heating.

A steel giving better results than the best acid open-hearth metal is said to be produced from basic pig, and the hotter metal gives sounder castings.

Electric Ore Smelting.

Considerable success has been achieved in the smelting of iron ore in countries such as Sweden, France, and South America, where water power is available and electrical energy can be obtained cheaply; also when the surrounding conditions and the nature of the ore are against ordinary blast-furnace practice.

Keller, of Livet, has spent much time and money in investigating this problem, and his latest furnace consists of two vertical shafts connected by a horizontal channel. The carbon electrodes are suspended in the shafts, through the bottoms of

which carbon blocks are inserted. These are connected by an outside cable. The ore mixture is fed into the shafts, and the current at first passes through the charge, the carbon blocks, and the cable; but as the hearth fills with molten metal the current passes through it by preference, and the cable may be cut out of the circuit. A third carbon electrode passes through the roof of the connecting channel and keeps the metal in it molten by arc-heating. The metal and slag are tapped from the central hearth.

The Grönwall Furnace.—This is one of the latest and most efficient furnaces for ore reduction. It is in use at Trollhätten, Sweden. It is of the shaft type, with an enlarged hearth, and when first put into operation is run as a blast furnace, but when the hearth contains molten metal the blast is cut off and electric heating only is used for the rest of the run. The electrodes are situated in the top of the hearth, which is lined with magnesite bricks, but even in this case the highly refractory nature of the bricks would not prevent the rapid destruction of the lining owing to the high temperature in the neighbourhood of the arcs. This, however, is largely prevented, and the life of the lining prolonged, by forcing part of the comparatively cool furnace gases from the top into the hearth, where they have a cooling effect. In addition the gases contain carbonic oxide, and on escaping from the hearth through the shaft exert a reducing action upon the descending charge of ore. It is said that only one-third of the coke or charcoal which would otherwise be required for complete reduction of the ore is used under these conditions. The successful working of this furnace is largely due to the economy thus effected.

The ore used is Swedish magnetite, and charcoal is replacing coke for reduction. The pig metal produced is of exceptionally good quality, being low in sulphur and phosphorus, although the phosphate content of the ore is fairly high. A furnace 25 ft. in height, with a hearth of about 8 ft. in diameter, is calculated to produce from 150 to 200 tons of pig-iron per week. The energy absorbed by this furnace is about 2,000 h.p.

Electro-Metals, Limited, are specialising in the construction of electric smelting furnaces for use in districts where water power is available and coal is dear. According to Mr. Bibby, they had installed 17 electric blast furnaces, and others are in course of construction. Those already at work have a capacity of 4,000 h.p., but this will probably be increased to 12,000 h.p., with an output of some 350,000 to 400,000 tons of pig-iron per year. Undoubtedly the pig-iron is of superior quality, being low in silicon, and although it has a spongy texture on this account it works excellently in the steel-making furnace. It probably resembles "washed" iron more nearly than the best quality of B.F. white iron.

It has been suggested that the relatively cheap power derived from blast-furnaces gases might be utilised for electric smelting; but it must be borne in mind that there are many uses to which such gases are put in large iron and steel works, and it is doubtful if very much will be done in this direction unless producer gas is introduced to assist.

Induction Furnaces.

In order to make clear the general principle upon which the construction of these furnaces depends it will be well to refer to the principle and construction of the transformer. The voltage of the current which leaves an alternator is given by:—Volts$=\frac{L \times S \times R}{108}$, where L equals number of loops in the coils, S equals strength of magnetic field, and R the number of revolutions of machine. Therefore the tension or pressure of the current leaving the machine may vary considerably within certain practical limits, but with very high tension the current quantity will be relatively small, for the mechanical energy leaving the machine is roughly measured by the watts leaving it, and as watts equals volts × amps., the higher the tension the smaller the current quantity.

It is more economical to produce high-tension current at the power station, especially if it has to be conveyed some distance for use. But, as the heat generated equals C^2R, and the pressure employed is comparatively low, a heavy current is required for furnace working. But there is no difficulty in transforming H.T. currents into L.T. currents with very little loss. The principle of the transformer is very simple. A continuous soft iron core is wound with two sets of insulated coils having no electrical connection. The one coil consists of a large but definite number of turns, and is called the primary coil; the other, of a much smaller number, forms the secondary coil. This is the simplest form of transformer, and is used for single-phase current. For two-phase and three-phase current the windings for the transformers will be more complex.

Suppose, for example, that, in single-phase transforming, a current of 10 amps. at a pressure of 1,000 volts is passed through a primary coil of 1,000 turns, and acted by induction upon a secondary coil of 10 turns, then, leaving out small losses, a secondary current of 1,000 amps. at a pressure of 10 volts would flow through the secondary coil.

The capacity of transformers varies with the load they have to carry, and is expressed in kilovolt-amperes. Thus a 10-k.v.a. transformer would be required in the above example, assuming a power factor of unity; but for large furnaces they would be from 1,000 to 1,500 k.v.a.

If the secondary consists of a single ring of metal its cross-section may be such that the heat generated in it by the passage of induced current will be sufficient to fuse the metal, and if the ring is lying in an annular space lined with refractory material the molten mass may be raised to a still higher temperature. This is the principle upon which the construction and working of all induction or transformer furnaces depends. The first examples of these furnaces were designed and patented by Ferranti in 1886 and by Colby in 1887.

The Kjellin Furnace.—This was the most successful of the early forms, and was doing good work at Gysinge Bruk in 1900. It is circular in section, and the hearth consists of an annular space in the masonry, lined with either acid or basic refractory material, and fitted with a circular cover made in sections so that parts of the hearth may be examined without exposing the whole. A massive iron core, rectangular in section, is arranged with one vertical limb within the ring and the other outside, the two being joined at the top and bottom by heavy iron yokes. The inner limb is surrounded by an insulated coil of many turns to form the primary circuit, and the metal in the hearth forms the secondary circuit. Alternating current of 80 to 90 amps. at a pressure of 3,000

volts generates a secondary current of some 30,000 amps. at 7 volts in the ring of metal, which is raised well above its melting point so that refining may be carried out. A furnace 12 ft. in diameter and 8 ft. high has a capacity of 35 cwts. In ordinary working 20 cwts. would be tapped from the furnace, and 15 cwts. left in to continue the transforming while the fresh charge is added.

The Röchling-Rodenhauser Furnace.—In the description of the induction furnace given above, only the general principle is exemplified, but it is evident that side issues must present themselves. To prevent eddy currents in the iron core, with consequent waste of power, it is made up of thin sheets of soft iron insulated from each other by layers of paper. The parts which carry the primary winding have their horizontal section in the form of a cross. This economises the winding and leaves four vertical channels through which air can be circulated to keep the coil cool. Further, the coil, if exposed, would be heated by radiation from the surrounding masonry. To prevent this, the coil is enclosed in a double jacket of thin sheet brass with a wood joint from top to bottom to prevent short-circuiting. A continuous current of cold air through the jacket and coil keeps it within the temperature limit. The magnetic field due to the current in the primary coil is largely concentrated in the iron core, but there is a stray field outside, and this means waste of power. Rodenhauser placed a short circuit of copper bars in this field, and connected the open ends with iron pole pieces built into the opposite side of the main hearth and directly behind the refractory linings. As this is either magnesite or dolomite it becomes a conductor when hot, and the current induced in the copper circuit flows through the bath of metal. The resistance of the metal to its flow generates more heat, which accelerates the refining.

In the general arrangement of the furnace both limbs of the iron core are fitted with primary coils protected as above, and the hearth consists of two relatively narrow annular portions, encircling the limbs of the core and connected by a wider channel running from back to front of the furnace and forming the main hearth. The refractory brickwork of the annular parts is so arranged that only metal can circulate in them while the slag blanket is kept in the connecting channel. This prevents too rapid corrosion of the refractory lining, which is not so readily got at for repairs as is that of the main channel. It was soon found that a tilting furnace is much more readily handled than a stationary one, and all recent furnaces are of this type.

The author remarked in conclusion that his object was rather to draw attention to the main principles governing the construction and working of electrical furnaces rather than to give minute details of any one furnace or process. The published matter was so extensive that a reader desiring more details could easily obtain them.

THE CHAIRMAN said that electric furnaces were never taken advantage of in England as they had been on the Continent until the war compelled them to utilise such furnaces, and very few foundries in the Kingdom had treated the subject as seriously as it deserved. There was no doubt that many of the faults in steel castings had been due to the low temperature at which they had been poured. The gases had remained in the metal because the latter had not been sufficiently fluid to drive them out. No doubt, with the introduction of electric furnaces many of these blowhole troubles would disappear. Steel makers throughout the trade were realising more generally than ever the great opportunities which such furnaces placed in their way, not only to secure better metal, but to enable them to effectively compete with the great establishments on the Continent.

MR. I. E. LESTER (President of the Birmingham Metallurgical Society) said he had had some experience in the direction mentioned by the chairman, namely, blowholes in steel, and such blowholes occurred in connection with Siemens acid steel, Siemens basic, and in crucible steel. The question of high temperature was a very important one in its relation to the inclusion of gases in the metal, and it was a matter which ought to be very carefully studied. When dealing with steel he preferred what was known as a "dead melt," and that was the time when steel was melted to a very fine point, and they had then in the steel, carbon, manganese, and phosphorus in various quantities. They wanted to be able to judge by the eye as to the temperature at which they were casting, not only before casting, but to know at an earlier stage whether the gases had been sufficiently evolved before they got down to the low pouring temperature. It would help them very much if the gases had been got rid of before that stage was reached.

Referring to the question of refractories, he had been told that the reason why the electric furnace had not been so successful as could be wished was because the refractory materials were insufficient to stand the high temperature. Some time ago an interesting paper was published in connection with the Metallurgical Society on "Zirconium," and the Society was to have a further one by the same author. The paper was published and was in great demand, and the interest arose very largely because of its exceptional value as refractory material. It was a material which could be used in the electric furnace in the place of magnesite. If it was possible to get a substitute for silica in connection with the acid furnaces and in the basic furnaces a very great step forward would be made.

MR. BRADFORD said that the vast demands for alloyed steels, molybdenum, and ferro-vanadium steels, had set up an enormous demand for the electric furnace. Mr. Lester had referred to zirconium. Undoubtedly the use of zirconium had latterly extended very widely in America. Prior to the war some 500 tons per annum of the crude Brazilian ore were shipped to Germany, which country used it almost exclusively, and he believed it was used for linings in electric furnaces, but that outlet had been cut off. Whatever zirconium ore was now being used was obtained from the Brazilian district and was being shipped to this country and possibly to America. He did not wish to say too much at present about that metal. He had himself devised a method for the manufacture, which was now being tried experimentally on thermo-electrical lines. It had not yet come into use, but the experiments were in the direction of producing it crystalline. That was intended for the production of fine ware. For the ordinary furnace the Brazilian ore which contained about 75 to 84 per cent. of zirconium seemed to be eminently suited for furnaces in use in Birmingham. Dr. Rosenhain made some experiments two or three years ago with regard to the use of zirconium in metallurgical furnaces at the National Physical Laboratory. He had understood that the Doctor was not satisfied with the result, but his

(the speaker's) impression was that the experiment was not continued for a sufficiently long time. However, Dr. Rosenhain was satisfied that the crude ore containing 74 per cent. of zirconium would answer the purpose of the electric furnace very well. He did not seem to have continued his experiments, but those in touch with the subject and the European agents of the Brazilian mines had informed him (Mr. Bradford) that the zirconium industry was being developed largely in America, not only in regard to the production of zirconium steel, but with the idea of producing linings for the electric furnaces. The temperature necessary to melt pure zirconium was in the neighbourhood of 2,950 deg. C., and he thought they would admit that that was certainly the most refractory oxide in common use. He understood that there was a still higher refractory, which was boron nitride, but that was out of the question as regards price. Really the most refractory oxide was pure zirconium, though the addition of impurities lowered the melting point rather considerably. With a material containing 80 per cent. of pure zirconium it was quite easy to stand a temperature between 2,000 deg. and 3,000 deg., so that in the future the use of zirconium for the lining of electric furnaces must be regarded as a well-established thing. He had been in touch with one of the biggest makers of furnaces in this country, who had been experimenting, and he found it quite satisfactory, but at present they did not know sufficient of its behaviour, though he thought it was quite possible during the next twelve months that the cost of it might be considerably brought down.

Mr. Westwood said that it would interest some members of the Association to know a little more about the practical working of the electric furnace. He used a 25-cwt. furnace, which differed in construction from all the other furnaces he had ever had to do with. It was lined with amorphous carbon about 1 in. thick, and on the top of that they placed magnesite bricks of about 3 in. square, and on the top of that was some calcined porphyry, rammed in with red-hot rammers. That, again, was covered with a lining of brick, the bricks being the ordinary silica bricks used generally in the steel furnace. He had noticed in the refining process, especially when the first slag had been taken off, that the metal had been allowed to settle for a few minutes. There were quite a number of ripples on the hot surface of the steel, as if something had been thrown into the furnace just as a stone might be thrown into a pool of water, and as if current was being introduced through the bottom, causing a motion in the steel and thereby helping to thoroughly mix it up. His experience of the first charge was that just when the slag had been taken in and the steel was coming to the point where they wanted to add manganese, they saw the metal trickling through the bottom. They took off the current for about five minutes, when the downward flow ceased and it was all right. He had installed a furnace, but, unfortunately, after the furnace was in working order the enterprising Corporation of Birmingham told them they could not supply any more current. The result was that, after installing plant at a cost running into four figures, they were obliged to dispose of the furnace until the end of the war, but they managed to get two hundred heats out of the furnace without having to renew the bottom. Really the only trouble was the roof. If they allowed the furnace to cool down they found, when they started up again, that the bricks in the roof had a tendency to crack, and half of them might drop into the metal. When the furnace builders managed to overcome that difficulty they would have at their service an ideal furnace which would give a clean metal. The furnace he had referred to was a 25-cwt. furnace and was 3 ft. in diameter. They had not a single failure, and they were really working it very successfully. When they could get their current at 0.4 to 0.5 of a penny per unit then the use of current would become commercially profitable. He could only say that he was perfectly satisfied with the electric furnace as far as he had tried it.

Mr. Stansbie, in reply, said that undoubtedly the one matter which ought to be really considered was the enormous waste of fuel that was constantly going on in this country and, he presumed, in other countries. It had been calculated that the energy of coal was equal to 0.005 of a penny per kilowatt. If they could get current at ¼d. per unit they could do some excellent work very economically. What he wanted to know was what became of the other 99 parts of the energy in coal, because 0.5 was 100 times .005, and there must be an enormous loss between the capacity of the coal and the energy which was outlined in the electric furnace or, indeed, anywhere else. He presumed they did not get more than 15 per cent. of the useful energy between the coal and the boiler and the current in the generator. Beyond that 15 per cent. there was a difference more or less of waste. To burn coal under boilers in order to obtain steam was no doubt a very wasteful way of burning fuel of any kind. The best method they knew at present was the burning of gas in the cylinder of the gas engine, and in that way a considerable amount of energy could be saved. He remembered speaking to a man in an iron works some time ago who told him that he could produce current at 0.3 of a penny per unit, which was considerably lower than any estimate mentioned in the course of the discussion, and he was making that current out of producer gas. If they turned to the blast furnace, which would never go to the wall in spite of the electric furnace, there they had a very much cheaper source of energy than ordinary producer gas. He was in an iron works where a furnace was being built for the generation of energy at a very low figure, probably about 0.1 or 0.2 of a penny per unit.

Another point he had argued was that their use of fuel was too much distributed. He would like to hear something practical in regard to pit-head consumption of gas. They could burn their coal at the pit head and turn it into current and then send it away anywhere within 400 or 500 miles. He felt certain that there was a great future for pit-head production of electrical energy, and also pit-head production of gas, but he was afraid that would not come about at present. With regard to blow-holes, he believed that was really a matter of temperature alone. Mr. Howell had referred to carborundum as a very refractory material. He had often wondered if that could not be used for the linings of electrical furnaces. No doubt zirconium was the coming thing, and he agreed with Mr. Bradbury that it was quite the proper thing for roofing purposes, but not for the beds of furnaces. One reason was that the temperature was never so high at the bed of the furnace, and, in fact, they very often could not get the bed of the furnace hot enough. It was the roof and the side walls that suffered from unsuitable linings.

Synthetic Cast-Iron.*

By Charles Albert Keller (Livet, France).

Synthetic Cast Iron, its Origin and Development.

[Extract.]

"Synthetic cast iron" is the term by which, since the commencement of its manufacture in the electric furnace, the author has always described the iron obtained by the recarburising melting of steel turnings. This term has since passed into metallurgical currency, and has now become generic. The novelty of its manufacture consists in carburising iron and steel scrap, more particularly turnings, by melting these materials in the presence of carbon, which is introduced simultaneously with them in the melting appliance. The electric furnace is plainly indicated as best fulfilling all the conditions required for the carrying out of this operation. Only a process of continuous carburisation, effected during the course of melting a mixture of steel turnings and carbon† could conduce to an economic method of producing synthetic cast iron with a commercial future capable of development as other than a mere war emergency.

The preliminary melting of steel turnings in a bricked-in furnace necessitates the consumption of an amount of energy corresponding with the temperature which has to be developed in order to melt the steel. It must further be remembered that the thermal efficiency of a furnace of this type is lower than that of an open-type furnace constantly replenished with materials for melting, and the walls of which are much cooler. On the other hand, charging turnings into a closed-in furnace, with doors, involves technical difficulties. These disadvantages, however, are but small in comparison with those accompanying the actual carrying out of the carburisation in the two instances. The carburisation of turnings, after melting, can only be effected by solution brought about between the upper layers of the metal and the carburants. It becomes the more difficult, and the slower, the higher the percentage of carbon rises. The dense carburants employed are expensive, and the consumption of energy resulting from the slowness of the carburisation becomes considerable. As the furnace has to be emptied after each heat there must likewise be taken into consideration the heat losses inseparable from this operation, as well as the repairing of the hearth, sides and roof, none of which arise in the continuous running of an open furnace.

In an electric furnace charged with steel turnings mixed with carbon the carburisation is not only absolutely controlled by the known reactions of the substances present, but it should be noted as an important economic advantage that the combination of the carbon with the iron begins in the upper parts of the charge long before actual fusion. Cementation intervenes from a temperature of 650 deg. upwards and becomes more rapid in proportion as the temperature rises, owing to the descent of the charge.

Carburisation of the iron takes place subsequently, by the contact between the solid carbon and the partially carburised metal in the course of melting, and becomes complete on full melting, the temperature of which is determined by the nature of the iron, so that casts can readily be obtained in the electric furnace at temperatures of 1,200 deg. to 1,300 deg. C.

The mixture of steel turnings and carbon possessing, in itself, very high conductivity, it would become necessary, to ensure normal working in the electric furnace, to use so low a potential that higher currents than those ordinarily in use could be employed. On the other hand, it would be a pity to employ electric fusion without profiting by the metallurgical advantages involved, in order to effect desulphurisation. The introduction of basic slag into the charge meets these two requirements and accomplishes two results, subsidiary and supplementary to the carburisation and necessary to the complete practical success of the process, namely: (1) The lowering of the conductivity of the mass to be treated by the introduction of a non-conducting material amongst the conductive materials (turnings and carbon), thus enabling fusion to take place under ordinary thermo-electric conditions, and (2) complete and easy desulphurisation of the resulting metal.

Thus carried out, the process may be described, from the metallurgical point of view, in the following terms: The iron obtained in the presence of a sufficiently basic slag, which combines with the small amount of silica introduced, will contain practically all the substances contained in the charge, except the sulphur. There will be no increase in the silicon, and the carbon in the charge will be used up solely in carburisation, without any appreciable intervention of the silica. White cast-iron can thus easily be obtained with ordinary steel turnings. With turnings containing 0.44 per cent. of silicon, 0.55 per cent. of manganese, and 0.07 per cent. of sulphur a white iron of the following composition was obtained: Carbon, 3.55 per cent.; silicon, 0.52 per cent.; manganese, 0.48 per cent.; sulphur, traces. Hence control of the percentages of silicon and of other elements becomes easy; for example, extra silicon will result from introducing more silica into the charge, along with a corresponding amount of carbon for reducing it. The percentage of silica in the slag will vary according to the percentage of silicon in the iron.

The certainty with which the above considerations can be relied upon allows of the process of manufacture described by the author being regarded as complying absolutely with the predetermined calculation of the charge, and as corresponding absolutely with the estimated amount of the elements contained in it. He can afford a proof of the truth of his conclusion by adducing an instance of an electric furnace with a capacity of 80 to 100 tons per 24 hours, which has not given rise, over a month's working and while specially watched for that purpose, to variations exceeding 0.25 in the results of carburisation and of siliconisation respectively.

It will have been thoroughly understood from what has been said that control of the composition of the slag must be strictly exercised; also that the amount of carbon introduced must be accurately known. The process being one of great accuracy, is correspondingly highly sensitive. It is necessary, therefore, to rely entirely on the help of the chemical laboratory.

The carbon employed for carburising should correspond, so far as its physical condition is concerned, with the size of the steel turnings, so that the contact between the particles may be as perfect as possible, and so as to facilitate carburisation in the higher portions of the furnace charge. Small coke is highly suitable, and so is wood charcoal. Either may be used, according to price and to the degree of purity sought.

The system that has been described is one of extreme simplicity. It does not require any skilled workman as the results sought are independent of any technical manipulation except in so far as the preparation of the charge is concerned, and depend entirely on an accurate knowledge of the composition of all the components.

* Paper read before the Iron and Steel Institute.

† French patent Ch. A. Keller, No. 405277 of November 10, 1908, and certified addition No. 19358 to patent of September 11, 1913, and English patent No. 22692 of October 8, 1913.

The electric furnace, fed continuously by the charge, works regularly and with very small losses, as the heat transmitted by the electric hearth situated immediately beneath the charge is, to a very large extent, utilised in heating up the materials, and effects a preliminary carburisation prior to melting. This enables the consumption of electrical energy to be reduced to as little as 675 kw.-hours per ton of pig in a 2,500-kw. furnace of 80 to 100 tons. Maintenance of a furnace, working in the manner described, is barely appreciable, seeing that with a six months campaign at Livet the above furnace did not require any repairs either to linings, shell or any other part. The lining only needed some attention when the furnace was put out of action owing to the water power supply failing.

The fundamental economic considerations in the manufacture of synthetic pig are as follows: (1) The electrode consumption can be lowered to as little as 6 kg. per ton, with electrodes of good quality. (2) The consumption of unoxidised turnings is 1,050 kg. per ton of iron, a figure which, even with moderately rusty scrap, becomes only a little over 1,100 kg. (3) The amount of coke with 80 per cent. fixed carbon required to produce a ton of strong pig-iron with 3 per cent. of carbon and 1.75 per cent. of silicon, starting with normal turnings of shell steel, is about 80 kg. (4) A furnace of the 80- to 100-ton type should be provided with mechanical appliances for upkeep and charging, so that its operation does not require more than fifteen workmen for the preparation, by hand, of the charge, for charging, and for regulating the furnace. (5) Tapping, and loading up on trucks as required, needs seven men per unit, and handling in the stockyard another two men.

The general economy of the process, combined with the simplicity of the method of carrying it out, leads the author to believe that while synthetic iron found a very wide field of application during the war, owing to the very large production of steel turnings derived more particularly from shell manufacture, it will find no less a field after the war in, for example, producing those steel-like qualities of material required for highly resistant mechanical parts.

The most obvious plan to adopt is to lay down a foundry for such parts adjacent to the synthetic cast-iron plant, as has been done at Livet. In such a case the foundry iron from the primary furnace may, if preferred, be made use of by transferring it to an electric mixer which can mix several casts and thus keep any quantity of metal ready for castings. This mixer, of the steel-furnace type, allows of the quality being ascertained by samples being taken before casting. It is needless to dwell at any further length on the method in question.

The manufacture of malleable cast-iron is likewise easily accomplished in the electric furnace, as the general quality of the steel turnings enables the low percentage of silicon and manganese required to be readily obtained, the reduced percentage of carbon present being dependent on the composition of the charge. It will also be seen that synthetic cast iron may find a further field of application in the manufacture of special pig, by means of special additions, such, for example, as nickel, chromium, etc. In such cases benefit will be derived, in making this kind of iron, from the absence of hydrogen, nitrogen, carbonic oxides and occluded air.

So much, therefore, for the cast iron obtained under desulphurising conditions. The metallurgical value of the results obtained by the process alter completely when it becomes a question of dephosphorisation, which the author has practically accomplished by means of a dual process.

In the first place the steel turnings are melted in the presence of a small quantity of carbon and of a basic oxidising slag. It is necessary to aim at a critical carburisation which must be as high as possible, in order to lower the temperature of working and to facilitate the casting of the metal, while at the same time effecting dephosphorisation. A percentage of 1 or slightly over realises this object.

This first-stage dephosphorised metal, containing low percentages of silicon and manganese, is, according to circumstances, either cast into small ingots which are subsequently melted in an open furnace, mixed with the necessary additions of carbon and a desulphurising slag composed of materials containing exceedingly little phosphorus, or else poured into a second furnace of the bricked-in type, and covered with a layer of anthracite for recarburising. The synthetic cast iron produced is controlled in respect of its silicon and manganese percentages by the addition of oxides and of a corresponding amount of reducing carbon, in the ordinary way. This mode of working somewhat increases the cost of production during the first phase, and further necessitates, in the second phase, a converting cost equivalent to that of manufacturing ordinary synthetic cast-iron. About 1,500 kw.-hours must be allowed for the two operations.

The higher costs of manufacture are balanced by the higher value conferred on the synthetic cast-iron by reason of its extreme purity in regard to phosphorus, and likewise its purity from sulphur and its uniform composition in respect of silicon and manganese. From the commercial point of view such material can compete with Swedish iron.

The author will conclude this account of the chief metallurgical results obtained with synthetic cast iron by describing an alternative process* which he has been led to contemplate in connection with the manufacture of steel from steel turnings.

As in the preceding example, the steel turnings are melted in an open furnace fed by the charge, but the slag, instead of being oxidising, is desulphurising, and the quantity of carbon introduced with the charge should be sufficient to reduce the oxides in the turnings and to carburise the metal to an extent distinctly above the percentage of carbon sought in the steel, so as to facilitate the pouring of the desulphurised metal and to allow of an oxidising working in the second stage of the operation.

For example, if a steel with 0.5 per cent. of carbon be required, the metal in the primary furnace may be poured at 1.5 per cent. of carbon. It will, as has been said, have been freed from sulphur during melting.

The secondary operation, which can be either in an open-hearth furnace or in an electric furnace, refines the metal and brings it to the required carburisation, while at the same time dephosphorising it. It then remains to bring the metal to the proper carbon content in the ordinary way by final additions.

The production of synthetic cast iron during the war has been considerable. It is not possible for the author to estimate at the moment how much has been produced at works other than those administered by the Keller Leleux Company at its works at Livet, Nanterre, and Limoges. The production of these three works alone exceeded 150,000 tons, while it should further be pointed out that Nanterre has been devoted to other manufactures within the last eight months. It goes without saying that such an output could not be obtained solely from existing plants, but required a special industrial effort for the creation of new plants. These new plants are the subject of the second portion of this Paper.

The Process.

Directly after the specifications for projectiles of semi-steel appeared, the author took steps to produce a metal complying with the conditions laid down by the French Ordnance Department. By November, 1914, such an iron had been produced and investigated, corresponding with the following composition:—Carbon, 2.9 per cent.; silicon, 1.75 per cent.; manganese, 0.50 per cent.; sulphur, traces; phosphorus, 0.05 per cent. The test results obtained were as follows:—Tensile strength, 50 kg. per square mm.;

* French patent Ch. A. Keller, No. 81928 of December 29, 1915.

impact resistance, 60 blows (equivalent to fall of a 12-kg. tup from a distance of 89 cm. on a test-piece measuring 40 mm. by 40 mm., resting on two knife-edges 16 cm. apart, the distance of fall increasing 1 cm. at a time until rupture occurs), whereas the ordnance requirements only specify a minimum of 25 kg. per square mm. for the tensile strength and 18 blows (equivalent to 44 cm).

The first electric furnace, of 20 tons, was started in 1914. The uniformity of the iron and the tensile qualities obtained led to its being immediately considered from the standpoint of shell manufacture. The Ordnance Inspection Department, after due examination, showed itself favourable, and before the end of 1914 the first series of 220-mm. shells of semi-steel yielded excellent results at the Bourges proof range. Orders from the Department were the immediate result of these favourable trials. The manufacture of 220-mm. shells of synthetic semi-steel was thus undertaken at Livet on a commercial scale from the commencement of 1915. A complete foundry was erected and furnished with electric furnaces for the refining of the iron, and the production, which was in the first instance at the rate of 50 shells per day, was raised in 1916 to 300 220-mm. shells, together with 10 high-explosive 400-mm. shells, requiring 55,000 kg. of raw metal.

In order to comply with the best practical conditions for running the foundry, the iron obtained in three primary furnaces is run into a ladle of 5 tons and poured into three 7-ton electric mixer furnaces, each taking 400 kw., to reheat the metal if necessary, and in any case to keep it hot during the period that iron is being used, and to check the quality. Despite the very uniform composition of the primary furnaces a carbon test, which only takes twenty minutes, is carried out by the foundry staff before pouring, in addition to ascertaining the quality by a quench test which serves more particularly to check the silicon.

The mixer-container furnaces for steel are of the Ch. A. Keller type, that is to say they have a roof and doors. The electric current enters by a vertical electrode, and leaves through the conducting hearth, of the reinforced-puddle type (vertical bars plunged into tamped magnesite). A conducting hearth of this description is practically unwearable, being non-susceptible to any cracking. If the bottom conducting surface of the hearth wears gradually lower, repairs are very easily effected by spreading over the bottom, while still hot, a special conducting puddle consisting of magnesite and fragments of iron mixed in tar. All holes are thus easily filled up without either the framework or the working of the hearth being interfered with in any way. From a metallurgical point of view this method of repairs corresponds in principle with that employed for the hearths of open-hearth furnaces. The furnaces are, of course, of the tilting type which allows of any quantity of metal, no matter how small, being drawn off.

The liquid iron poured in is covered with basic slag, which forms a protecting layer, preventing oxidation and breaking the electric arc. When pouring is to be done, this layer is easily retained by a little brickwork or sand pocket at the entrance of the furnace spout.

Practice has shown the advisability of interposing these mixer furnaces, which keep the metal so that it can be checked from time to time by the technical staff, who thus acquire a high degree of skill, seeing the ease with which the metal can be held waiting. Generally speaking, it may be said that the metal remains an hour in the mixer furnace, including the time of pouring, for the filling up of these furnaces is carefully adjusted to correspond with casting operations in the foundry. The metallurgical adjustments are very easily carried out, as any additions, as well as the withdrawal of the test samples, are effected through the working door. The practice described gives complete satisfaction; in particular it invariably ensures uniform metallurgical results, thus eliminating all rejections due to insufficient tensile strength.

The upkeep of the mixer furnaces is but trifling. The interior lining of the mixer lasts a couple of months, and the roof over three months. The electrode consumption is on an average 2 kg. per ton of iron; the average power consumption is from 50 to 100 kw.-hours per ton, according to the conditions prevailing in the foundry. A single workman is required for the working of the furnaces, and he also looks after the tapping, the electrical manipulation of the tilting arrangements, and the taking of samples.

The machining of the shells, which was originally placed out with sub-contractors, was carried out at the Livet Works towards the end of 1916 under Ordnance inspection, and thus without the intervention of any transport, or the use of any coal except for the chemical composition, the manufacture of semi-steel shells from steel turnings was wholly carried out in one works. This concentration of plant reduced the number of rejections to a very small amount, not exceeding, when the necessary skill had been attained, 7 per cent. on the cast shells inspected.

The capacity of the electrical foundry at Livet could not keep pace with the output of casting metal, which began at 20 tons per day, was subsequently increased to 60 tons, and later on reached not less than 300 tons during the period of maximum water-power supply. Several outside works manufacturing shell were supplied with the surplus output. These firms all testify to the uniformity and excellent quality of the iron supplied. The quality of the iron supplied to outside firms corresponds with the following composition which complies with the best metallurgical practice: carbon about 2.75 per cent. and silicon about 2 per cent.; so that after a cupola melting the artillery specifications could almost be met without any addition of steel, as both recarburisation and reduction of silicon accompany fusion in this type of furnace. Each wagon-load sent out was accompanied by an analytical report showing what additions of steel and of ferro-silicon might be needed. Very often no such additions were required.

New Works at Livet and Elsewhere.

A new special works was laid down in November, 1915, some hundreds of yards from the original works, with which they were connected by railway. The new works were started on July 12, 1916, first with a furnace of 80 to 100 tons, and were subsequently enlarged. The building occupied an area of 12,500 square metres, and comprised more particularly four parallel shops. The first shop, which was 300 m. in length, and alongside the railway, served for unloading the raw materials, and more especially the steel turnings, which are handled by means of a powerful electro-magnet suspended from a high-speed crane. The turnings are either used at once in the cycle of operations, or put into stock in a deep trench occupying a portion of the length of the shop, from which they are withdrawn by the same means. By this arrangement a 12-ton wagon can be unloaded in twenty minutes.

The second shop, which was situated between the unloading shop and the electric furnace shop, served for the preparation of the charges, which are mechanically raised by large bucket elevators to the furnace platform, where they are tipped on to the latter by small wagon-loads at a time and heaped around the electrodes. The transformers are housed in sheds built on reinforced-concrete foundations on the level of the platform of the electric furnaces.

The third shop contains five Ch. A. Keller furnaces of the "electrodes in series" type arranged in line, four being of 2,000 kw. and one being of 2,500 kw. The output capacity of this installation is 300 tons of synthetic iron per day. This output could not be maintained, particularly in 1918, owing to various circumstances which were, however, quite independent of the plant itself.

Moulding Sands for Non-Ferrous Foundry Work.*

By P. G. H. Boswell, D.Sc., F.G.S.†

(*Extract.*)

Introduction.—The technique of casting non-ferrous metals and alloys carries with it problems peculiar to itself. The difficulties that have arisen in works' practice have, for the greater part, been solved empirically—often by the safe but lengthy and expensive method of trial and error. So far as can be gathered from available literature, there seems to have been little scientific investigation into the difficulties which are sometimes met with in non-ferrous moulding-sand practice, although the very different effects on the structural strength and physical properties of castings made in sand and metal ("chill" castings) have been carefully worked out and recorded.

After observing moulding-sand practice in numerous foundries at home and abroad, the writer feels that, as in the case of many of the problems arising in steel practice, but to an even greater extent, the success achieved in non-ferrous founding is more dependent upon the individual skill of the moulder or foreman than upon the application of scientific knowledge.

It may be desirable to amplify this statement to some extent. Steel is frequently cast at a temperature of above 1,600 deg. C., and sometimes (when made in converters) above 1,650 C. Such temperatures may be higher than the softening point, and well above the inversion points, of silica, which, as the mineral quartz, constitutes 80 per cent. or more of moulding-sands. The other constituents of moulding-sands (such as clay) fuse at lower temperatures. The elimination of one of the most serious evils in steel-casting, that of "burning on," is therefore at present an unsolved problem, essentially scientific in character. In good foundry practice the trouble may be reduced, but it has never yet been entirely eradicated. The results that are produced vary, too, with the composition of the steel and the physical characters of the sand, both matters amenable to scientific control.

On the other hand, both iron and non-ferrous metals and alloys are "run" at much lower temperatures, which rarely exceed 1,300 deg. C. Most sands, when subjected to these temperatures for a limited period of time, remain essentially unchanged. The task of obtaining good sound castings in iron, brass, bronze, aluminium, etc., is rather one dependent upon skilful moulding technique than upon the chemical characteristics of the sand. Nevertheless, the investigation of the texture and physical properties of the moulding-sand used does lead to results of practical value.

Whilst the problems concerned with casting non-ferrous metals and alloys in sand are generally less difficult, on account of the lower temperatures involved, than those concerned with steel, the former carry with them certain peculiar difficulties which result from their increased tendency to oxidation, more ready vaporisation, greater mobility, and greater sand-penetrating power. These peculiarities make cast iron a much easier material to found.

As an illustration of these difficulties, it may be remembered that, despite the fact that the casting temperatures of a metal like lead or an alloy such as phosphor-bronze are comparatively low, the skin of the castings may be rough or veined on account of the penetrating ("searching") power of the molten material or the "burning on" of the sand. The production of semi-fused sand intimately mingled with the surface layers of the metal cannot always be definitely prevented. The problem is not an easy one to solve, for "burning on" may result during the casting of lead at a temperature of less than 800 deg. C., whilst it is usually absent during the casting of manganese-steel at a temperature reaching approximately 1,600 deg. C. That chemical affinity alone is not involved is clear from the fact that glassy silicates of manganese are readily produced at the surface of the mould; fortunately the greenish "glass" adheres to the sand, and not to the metal of the casting. It seems that, having only the present data in hand, we can do no more than speculate, and until we succeed in obtaining the facts that indicate the relation of the behaviour of metals and alloys during casting to their physical and chemical characters, the uncertainty will remain.

This peculiar behaviour of metals and alloys has, however, been countered to some extent empirically, as a result of works' experience, by paying due regard to the composition of the moulding-sand used. Penetration of the sand by very mobile metal may be prevented by using sands of finer grade and "closer" bond than those employed in steel or iron founding, and by ramming them more tightly. The venting and permeability of the sand to gases and vapours is in part voluntarily sacrificed, a course of action which doubly necessitates the complete "killing" of the metal before it is cast. Indeed, the moulding practice is deliberately framed to prevent the sucking in of air through the pores of the mould (particularly at the top) during the contraction of the metal. At the same time, it is doubtful whether "blow-holes" in the metal are produced, as it is sometimes claimed, by air entrapped in this way. The more probable explanation lies in the incomplete freeing of the metal from gases before casting.

Laboratory Investigation of Moulding-Sands.—The fact which strikes the investigator most in his research into foundry sands is the absence of reliable fundamental data. No correlation of the behaviour of the sands or metals or of the results attained in casting can therefore be made. The accumulation of the necessary empirical information is too big a task for a single foundry or an individual investigator. It should rather be carried out by some organisation such as the National Physical Laboratory, or better, the proposed research institution to be known as the Petrophysical Institute. Work of the character desired has been begun in the United States of America (where foundry technique is less advanced than at home) at the Bureau of Standards, and the results of some use-

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ful work have been published. The testing of sands in the laboratory is necessarily of a preliminary character only, and must be correlated with the results of actual practice in the works, where the final tests should be made. Laboratory investigation, involving the methods of both pure and applied science, cannot be dispensed with; there are too many unexplained and unexpected happenings in even the best regulated foundries to permit the ruling out of pure scientific research.

The laboratory testing of moulding-sands may be carried out along the following lines:—(1) chemical analysis; (2) mechanical analysis; (3) mineral analysis; (4) character and composition of the "bond," colloidal or otherwise; (5) compressive strength of sand-moulds and cores; (6) transverse strength of sand-moulds and cores; (7) tensile strength of sand-moulds and cores; (8) thermal conductivity of moulding-sands; (9) permeability; (10) porosity.

Adequate knowledge of the inter-relation of the properties of suitable sands as revealed by investigation along the above lines cannot fail to lead to the standardising of results and the elimination of haphazard methods. Some indication of what may be done in this way can be gathered from the above-mentioned accounts of tests carried out at the United States Bureau of Standards. The results obtained in works' trials should be correlated with the chemical and mechanical composition and the physical properties (specific heat, thermal conductivity, latent heat of fusion, etc.) of the alloys and metals concerned, as well as with the temperatures at which they are cast.

Chemical Composition.—When it is realised that many of the published records of chemical analyses are inaccurate and valueless, it is perhaps not surprising that such analyses are held in little esteem by foundrymen. The older published analyses in particular are unreliable. The precautions necessary to be taken in the carrying out of silicate analysis were unknown or unpractised. (It may be claimed, and perhaps with reason, that accurate methods of silicate analysis have been in vogue only within the last twenty years.) To take the case of one of the most important constituents of moulding-sands, the quantity of iron oxide recorded in the old analyses of well-known sands is noteworthy as being five or six times too great. A brief account of precautions to be taken in making chemical analyses of sands is given by the writer in a general publication on refractory sands.* Further particulars of which are given in Appendix p. 21.

On p. 3 it was observed that British sands used for non-ferrous work could be divided into two well-marked classes. One class, the Bunter sands, contains materials of the same geological age from different localities; such sands, therefore, show somewhat similar composition and properties. The other class, consisting of sands from various geological horizons, shows little uniformity in its constituents.

Mechanical Composition.—The fact that sands from either of the above classes yield equally good results in casting, emphasises the contention that in all foundry work the texture, or mechanical composition, of the sand is of great importance, and that in non-ferrous practice it becomes supreme. Mechanical analyses are made in order that the observer may determine the sizes of the grains present, and the relative weight of each portion between certain agreed limits of size ("grades").

The grading adopted by the writer and tabulated in Table I. is as follows:—

The gravel and coarser sand-grades in a moulding-sand may be estimated by screening, but it is obvious that the finer grades, down to clay, cannot be so separated on account of the difficulty experienced in manufacturing accurate sieves of very small mesh. Fine grades in sediments are separated by water-currents of suitably adjusted velocity, the process being known as elutriation. Moulding-sands are said to be "strong" or "weak," "fat" or "lean," "close" or "open," according to the quantity and character of the grades present. An "open" or "weak" sand is one consisting largely of the coarse and medium sand grades with very little fine clayey material. When a considerable proportion of clay-grade is present, the sand grains are bound together by clay films, and the material is said to be "strong." The presence of finer grades in a moulding-sand decreases its permeability to water and gases, and such a sand is said to be "close." The sands used for non-ferrous casting are closer and finer grained than those employed in steel-founding, where, although the bond is required to be strong, the sand must be exceptionally well vented to permit the escape of gases and vapours produced at the high temperatures which are reached.

Steel-moulding sands of the best quality possess a peculiar and characteristic mechanical composition, marked by the high proportion of coarse and medium sand grades, the relatively high proportion of clay-grade, and the low proportion or absence of the fine-sand and silt grades. The clay-grade exists as a film round each of the coarser grains, and by virtue of its power of taking up water acts as bond; the fine-sand and silt grades would, if they were present, reduce the permeability of the sand by packing up the pore-space, thus causing blowholes, scabs, etc., in the steel casting. In the founding of brass, bronze, and other alloys, the sand is required to be moderately close, partly in order that a smooth, clean skin

TABLE I.

Approx. I.M.M. Mesh.	G.	Greater than 2.0 mm. diameter	and less than 2.0 mm.	Gravel grade (G.)	
12–5	VCS.	" " 1.0 " "	" " 1.0 "	Very coarse sand	Sand grade (S.)
20–12	CS.	" " 0.5 " "	" " 0.5 "	Coarse sand	
50–20	MS.	" " 0.25 " "	" " 0.25 "	Medium sand	
120–50	FS	" " 0.1 " "	" " 0.1 "	Fine sand	
180–120	cs.	" " 0.05 " "	" " 0.05 "	Superfine sand or coarse silt	Silt grade (s.).
..	fs.	" " 0.01 " "	" " 0.01 "	Fine silt	
..	c.	.. ..	" " 0.01 "	Clay or mud grade (c).	

* A Memoir of British Resources of Refractory Sands for Foundry purposes.

may be yielded, and partly to prevent the penetration of the sand by the metal (and the formation of blowholes by the indrawing of air on its contraction). The temperature during casting being lower than that of steel, the mould does not require, if the metal is properly killed, to be so thoroughly vented. Not only is it prepared from closer sand (without the addition of silica sand to open it up, as in ferrous practice), but it is also more tightly rammed.

Mineral Composition.—The mineral composition of sands may be determined by certain special methods, but it is of less importance in the case of moulding-sands than either chemical or mechanical analyses. Nevertheless, a mineral analysis serves two useful ends. In the first place, it enables the investigator to interpret more satisfactorily a chemical analysis, for, in the latter, elements which are actually combined together to produce specific minerals are expressed as oxides. As an example may be quoted the sand from Wombourne, consisting of over 20 per cent. of orthoclase felspar, which explains the presence of 3.43 per cent. of potash (K_2O) shown by the chemical analysis. In the second place, it is frequently possible to identify a sand from its mineral composition, because deposits from different formations and various localities have been derived from different sources. The Bunter sands may thus be distinguished from those of Erith, Durham, Avenuehead, etc., but the limitations of the method are indicated by the fact that it would often be difficult to distinguish examples of the Bunter group of sands from one another.

Co-ordination of Results.—The inter-relation of the chemical and miner composition has been mentioned above, but from the point of view of practical applications, the bearing of the chemical and mechanical composition of a sand upon each other is of more importance. This inter-relation is shown by making chemical analyses, not of the ordinary sand but of the various grades as separated by elutriation. The Table II. indicates the results of such a series of analyses:—

TABLE II.—*Chemical Analyses of Grades; Bunter Moulding-Sand from Compton, near Wolverhampton.*

	MS. > 0.25 & < 0.5 mm.	FS. > 0.1 & < 0.25	cs. > 0.05 & < 0.25	fs. > 0.01 & < 0.05	c. < 0.01 mm.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
SiO_2 ..	94.37	89.10	85.21	69.05	58.17
Al_2O_3 ..	2.82	5.32	6.95	14.15	19.58
Fe_2O_3 }	0.46	0.88	1.23	2.70	5.47
FeO }			0.22	0.53	0.55
MgO ..	0.17	0.28	0.37	1.05	1.78
CaO ..	0.16	0.24	0.41	1.27	1.34
Na_2O ..	0.12	0.15	0.49	0.56	0.38
K_2O ..	1.57	3.13	3.31	5.45	5.37
TiO_2 ..	0.06	0.21	0.43	0.97	0.73
Loss on ignition	0.48	0.71	1.43	4.28	6.34
Totals	100.21	100.02	100.15	100.01	99.71

The most noteworthy features exhibited by Table II. are the decrease in silica percentage and the increases in the percentages of alumina, iron oxides, and the "loss of ignition" as the grade-size increases. The medium sand-grade carries a moderately high percentage of silica, with small amounts of alumina and potash. It may justly be classed as a silica sand, consisting of about 85 per cent. of free silica (as quartz) and 9 per cent. of potash-bearing felspar (orthoclase). Assuming that little or no mica is present, the balance of the alumina and silica would yield about 3 per cent. of clay substance (of theoretical composition, Al_2O_3, $2SiO_2$, $2H_2O$); about 0.5 per cent. of hydrated iron oxide also occurs.

The increase in alumina, ferric oxide, and the loss on ignition (the last-named consisting almost entirely of combined water), as the grades become smaller in size, points to the increase in the proportion of clay substance and limonitic matter (hydrated ferric oxide), which together constitute the "bond" of the sand. A mineral analysis indicates that muscovite mica (silicate of hydrogen, aluminium, and potassium) is present, and the quantity increases with decrease in grade-size down to, at any rate, the silt grades. Assuming, for the purposes of calculation, that it is absent in the clay grade, we find that the latter consists of about 21 per cent. free silica, 32 per cent. felspar, 36 per cent. clay substance, and nearly 6.4 per cent. of hydrated ferric oxide.

The most fusible constituents in a sand are the compounds of the alkalies, sodium and potassium, and of the alkaline earths, lime and magnesia. It has been stated that iron acts also as a flux in refractory materials, but the statement requires modification. Ferrous compounds tend to fuse rather readily, but certain ferric compounds, particularly the oxides, are highly refractory if the conditions, as is always the case in moulding-sand practice, are oxidising and not reducing. As an example, it may be mentioned that the bond of the most successful steel-moulding sands is largely hydrated ferric oxide, and to a less extent clay substance.

Since the alkalies yield more fusible compounds than the other constituents, it is evident that the mineral felspar is undesirable in a sand which is required to withstand high temperature. Felspar is accordingly found in small amounts only in the most refractory sands. For the casting of non-ferrous metals and alloys, however, the temperatures reached are not sufficiently high to cause the mineral to flux, and its presence (or past occurrence) in a sand may be of advantage on account of the contribution yielded to the bond of the material by its decomposition products.

Felspar in the fresh state is clear and colourless, being composed of the silicates of aluminium, sodium, potassium, and lime. Potash-felspar (orthoclase) is by far the most commonly occurring species in sedimentary rocks, and its decomposition may be taken as typical of the group. Orthoclase has a chemical composition corresponding to the formula Al_2O_3, K_2O, $6SiO_2$. "Weathering" causes it to lose its clear character and the grains or crystals become cloudy with decomposition products.

The carbonic acid gas of the atmosphere and soil frequently acts as the weathering agent, and in the presence of water leaches out part of the potash as carbonate, which is removed in solution. The result is the production of finely divided flakes of potash-mica (approximating to $KH_2Al_3(SiO_4)_3$ in composition. The formation of these tiny crystals of mica is frequently a resting-stage in the process, but eventually the whole of the potash is removed, and clay, which in its pure form is known as kaolin

or china-clay, of composition Al_2O_3, $2SiO_2$, $2H_2O$, is produced. The cloudiness seen in grains of partially decomposed felspar, as well as the clay substance often associated with them, is due to a mixture of fine micas and clayey material, which together constitute an excellent bond in a sand. The well-known Scottish "rotten rocks" are so-called on account of their friability, which has resulted from the decomposition of felspar originally present in the sandstone. These rocks are mainly used in iron and steel-casting, but a few, including that from Avenuehead, have been used for non-ferrous work.

It is noteworthy that the rolling out of clays increases their plasticity; similarly, the milling of moulding-sands increases their bond very markedly. Whilst milling should be sufficient to break down lumps of a sandstone into individual grains and to "knead" the bond round each, it should not be so heavy as to crush the quartz-grains. In the case of felspathic sands like that from Compton, milling doubtless crushes down the more decomposed grains of felspar, thus releasing an additional quantity of bond. The increase in the amount of bonding material as a result of milling is indicated by the mechanical analyses of the same sand from Wolverhampton before and after being treated in a pan-mill (see Table III.):—

TABLE III.—*Showing the increase in the amount of binding after milling.*

	C.S. > 0.5 and 1 mm.	M.S. > 0.25 and < 0.5.	F.S. > 0.1 and < 0.25.	S. > 0.01 and < 0.1.	C. > 0.01.	S. Total and grade. < 0.1 mm.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Before milling	trace	27.8	64.6	2.7	4.9	92.4
After "	0.2	20.0	59.5	12.2	8.1	79.7

The "Bond" of Moulding-Sands.—In metal-founding, the natural bond of moulding-sands is often supplemented by artificial bonds, such as treacle, flour, dextrin, sulphite-lees, etc. Many of these artificial bonds are, like clay and ferric hydroxide, colloidal bodies, which are characterised by their exhibition of surface phenomena—in this case particularly by their power of absorbing water. The weathering of many rock-forming minerals gives rise to colloidal bodies known as "gels." These colloids are apparently constituted with a honeycomb or cell-like pattern which enables them to hold considerable quantities of liquid. The water which is absorbed into the "cells" of clay is termed "micellian" water, and differs from hygroscopic water in that it cannot all be driven off at 110 deg. C. The plasticity of clays may be increased by an admixture of other colloids, such as colloidal silica, alumina, gallo-tannic acid, agar-agar, etc. The absorptive power of clay, in the matter of both gases and solutions, increases, according to Senfft, with the limonitic content. J. M. van Bemmelen showed, as long ago as 1878, that the amount of "hydrate water" of ferric oxide was variable and accidental. When just dry at 15 deg. C. the compound is able to take up over six molecules of water per molecule of ferric oxide. This fact throws interesting light upon the strength of the ferruginous bond in moulding-sands, and the power possessed by them of holding considerable quantities of water, without actually becoming wet. Some sands are able to take up as much as 13 per cent. by weight of water. For foundry purposes the smallest quantity of water, consistent with obtaining the required bond, should be used. The proportion is usually about 5 per cent., or even less.

The burning of clay for the purpose of making bricks is an everyday occurrence. The clay is thereby "porcellanised," volatile constituents such as water being driven off, and new minerals produced. The addition of water to burnt clay does not, in ordinary circumstances, produce the colloidal substance again. Hence the gradual wastage of a bonded sand in a foundry and its need of "revival." The foundryman asks that his sand shall be long-lived—that is, shall not dehydrate and "go dead" too readily. Where the hot metal touches the mould, the clay bond is undoubtedly killed, but not so the ferruginous bond. The sands with the longest life are often rich in the latter. Floor-sands in greensand moulding are frequently revived with such a sand as that from Mansfield or Birmingham, and in the case of dry-sand moulding these and other Bunter sands and also Barrow sand have been found to be very efficacious for the same purpose.

The ferruginous bond in moulding-sands is usually the cause of the production of a smooth sound surface to the casting, particularly in the case of steel. In non-ferrous foundry practice it is usual to ensure the smoothness of the skin by painting the surface of the mould, or "facing" it with a layer of finer sand ("facing sand") or a wash. The washes used for painting the moulds in non-ferrous work have usually either china clay or a graphitic material as a base. Graphite (plumbago) is itself sometimes used; at other times "Scotch blacking," which is a mixture of charcoal and graphite, is employed, and flour has also been used. A suspension of the powder in water may be assisted by the addition of a little borax or molasses.

For the making of "cores" in British foundries, "a compo" (or composition) moulding-sand is usually made up from an ordinary sand such as that from Mansfield, together with fragments of broken graphite crucibles, etc. The admixture of coarser material ensures the good venting of the cores. At times the sand alone is used. Oil-bonded cores (where the oil is generally a commercial linseed oil, such as "Baltic seed oil"), unlike those used in steel founding, have not met with success in non-ferrous founding at home, but they are adopted extensively in America, where a fairly coarse high-silica sand is the base. Sands from Lumberton and Howall, N.J., are so used.

The moulding-sand in common use for non-ferrous work in the United States is that from Albany, N.Y., and is remarkably similar in feel, texture, and behaviour to corresponding British sands like that from Erith ("Thames sand").

Distribution of Works and Sands connected with Non-Ferrous Foundry Practice.—Despite the widespread distribution of moulding sands emi-

nently suitable for casting non-ferrous metals and alloys, the number of different sands in general use, both in Britain and America, is remarkably small. Considerable transport is consequently involved, but, as will be seen from the following list of available resources, much of it could be avoided. Moreover, sands such as those used for casting iron, brass, bronze, etc., will not stand even so great a freight-rate as those used in steel manufacture, where the supplies are by no means so widespread. The margin of profit is too low, and the cost of transit too high, to permit such a commodity as sand to be unnecessarily carried from one part of the country to another.

The district par excellence for non-ferrous foundry work (brass, bronze, aluminium, etc.) is, of course, the Black Country in general, and Birmingham in particular. In Birmingham alone there are nearly 400 foundries concerned in the work, but it was a fortuitous circumstance that the city itself was built upon the red Bunter moulding-sand so valuable to the industry. Indeed, the sand has been worked in the heart of Birmingham, less than a mile from the Town Hall, for more than four generations, and has been used for the casting of gold, silver, nickel, copper, and brass, as well as the more modern work in phosphor-bronze, white alloys, aluminium, etc.

The exhaustion of the supplies of Birmingham sand being within sight, the resources of the adjoining area of the Bunter outcrop are being drawn upon, and Stourbridge, Wolverhampton, Compton, Wombourne, Kidderminster, and Stourport are now contributing their quota.

The metropolitan area is next in importance, but falls far behind the Black Country. It is served in the matter of moulding-sand by the excellent deposits at Erith, Charlton, Woolwich, and Rochester (both from quarries and dredged from the river bed). The Glasgow, Manchester, and Liverpool districts follow London in importance. The Glasgow area is in part supplied by Carlisle sand, partly by Scottish "rotten rocks," but largely by Belfast sand shipped across the North Channel. The Triassic sand from the Isle of Arran may prove of value in the future. (The Edinburgh-Leith district, which is less important, uses considerable quantities of both Erith and Mansfield sands, that from Erith being shipped in the Thames and unloaded at Grangemouth.) Manchester, like Birmingham, is built upon first-class moulding-sand, but the area is being rapidly built over. Supplies of sand for the South Lancashire area, including Liverpool, are also drawn from Ruthin, Ormskirk, Runcorn, Oldham, and the Wolverhampton country. Sheffield, Hull, Leeds, and Belfast rank next in importance; these districts (except Belfast) draw their sand from the Bunter deposits of Worksop, Hull, Hensall, and Mansfield, and from the glacial beds of Oldham, near Manchester. Permian sand from Pontefract is also used.

The industries on Tyneside and in the Tees Valley use sand from Erith (which has been waterborne), Durham, and Mansfield. Durham sand shows a remarkable resemblance to Erith sand in texture, chemical composition, and behaviour in the foundry—a fact not so well realised as it might be. South Wales draws largely upon the Bunter sands of Stourport, Kidderminster, and Belfast. The Nottingham-Derby district finds valuable supplies near at hand in the area from Mansfield to Nottingham.

Graphitisation Ranges of Temperature in White Cast Iron.

In a recent Bulletin of the American Institute of Mining and Metallurgical Engineers, D. Merica and L. J. Gurevich describe some investigations which they state were mainly undertaken in connection with other investigations on the properties and characteristics of chilled-iron car wheels, in particular to determine the best range of annealing temperatures.

Chilled-iron wheels are cast with a chill against the thread and the inside of the flange, the remainder being in sand. The composition of the metal is so chosen that under these conditions the tread and inside of the flange will show white iron to a depth of from $\frac{3}{8}$ to $\frac{1}{2}$ in. (15 to 22 mm.), the remainder of the wheel becoming graphitised or grey. In order to relieve the stresses set up during cooling under such drastic conditions, the wheels are stripped from the mould, while still red hot, piled in a soaking pit, and allowed to cool very slowly from their temperature at stripping.

Obviously, the most suitable temperature for this annealing is the highest at which no formation of graphite occurs within the white tread and at which the wheels can be stripped from the moulds. Inasmuch as no direct determinations have been made of the temperature at which the formation of graphite takes place in white iron of compositions used in car wheels upon annealing, it was considered worth while to determine these temperatures as a means of establishing the maximum temperatures at which the annealing of the wheels may be carried out. In the course of this work some incidental observations were made which are of interest in connection with the theory of graphitisation in white iron.

The Paper is summarised by the authors as follows:

The annealing or graphitisation ranges of temperatures were determined for three different compositions used for car wheels. The temperature of initial precipitation of temper carbon for six hours of annealing was not noticeably affected by variation of sulphur content from 0.10 to 0.20 per cent. or by variation of total carbon content from 3.60 to 3.90 per cent., although the effect of greater carbon content is to narrow the temperature range within which graphitisation is complete. The temperature of beginning precipitation of temper carbon was about 830 deg. C. for the 6-hr. period of annealing, and about 730 deg. C for the 48-hr. period. The maximum allowable temperature, therefore, for the annealing, or "pitting," of car wheels is about 730 deg. C. After complete decomposition of all free cementite by annealing at from 1,000 deg. to 1,100 deg. C and cooling at equal rates in a laboratory electric furnace, less graphite is found in a specimen cooled from 1,100 deg. C than in one of the same composition cooled from 1,000 deg. C. This indicates that graphite separates directly from solid solution upon cooling, when its nuclei are already present.

The fact that only 0.20 per cent. of combined carbon was found in some specimens after annealing at high temperatures and cooling slowly in the furnace, would indicate either that the graphite eutectoid lies at much lower values of carbon content than has been previously supposed, and that there is at those rates of cooling a direct precipitation of graphite eutectoid, or that there is a formation of graphite from pearlite at temperatures directly below that of its formation.

During the year negotiations have been entered into, and will shortly be completed, by which Stothert & Pitt, Limited, of Bath, will acquire the whole of the shares, plant, buildings, goodwill and other assets of the firm of Torrance & Sons, Limited, of Ditton. Messrs. Torrance have a large and increasing business in the manufacture of grinding mills and other machinery connected with the paint, etc., trades. The business is capable of large extension.

Castings Used in Ship Construction.

MOULDING PROPELLER BRACKETS.

By Ben Shaw and James Edgar.

Bracket No. I.

The following details regarding propeller-bracket moulding cover the two brackets, the patterns for which were described under Parts I. and II. appearing in our issues of July and September respectively. The successful preparation of moulds for propeller brackets requires considerable skill, and the ingenuity and initiative of the moulder is taxed in no small measure, not only in determining the most satisfactory means of forming the moulds with the minimum amount of tackle and in an expedient manner, but also in recognising the characteristics of the metal with which the mould is to be filled. In many steel castings special arrangements must be made to allow the casting every freedom during the critical period of cooling, and the ability to determine the vital parts of the mould which require to be weakened or eased in some way to allow the casting to contract with as little external resistance as possible, is an essential qualification of the skilled moulder. With the possible exception of the preparation of moulds for aluminium, no moulder has more difficulties to surmount with regard to shrinkage and contraction of the metal than the steel moulder. While the time has not arrived for the foundry's work to be set out systematically and scientifically in such a manner as to make the resulting castings a success beyond any doubt, yet much can be done to render unsatisfactory results a more remote possibility, and it lies very much with the moulder to secure this desirable condition. The pouring temperature of steel requires to be high enough to supply live metal, and as the range for successful pouring is smaller than with most metals, it is a factor which requires careful consideration. Given good metal at the right temperature and a good moulding sand of a highly refractory nature, with reasonable care in the preparation of the moulds, wasters might well be reduced to a very small percentage.

While the principles involved in the preparation of moulds for all large steel castings are similar, yet the method of their application vary considerably in different parts of the country. The methods adopted are usually determined by the practice previously resorted to, the equipment and capacity of the foundry having considerable influence in the decision. This is equally applicable to this example of a propeller shaft bracket, and while the methods described may not be superior to any other, still by these methods good castings will be successfully produced.

In this instance two methods are frequently resorted to, one having the central portion between the arms lifted in the form of a drawback, and the other where the pattern is simply bedded in, having drawbacks against each palm. In the former method, which is illustrated by Figs. 1 and 2, a bed is formed below the surface of the floor just

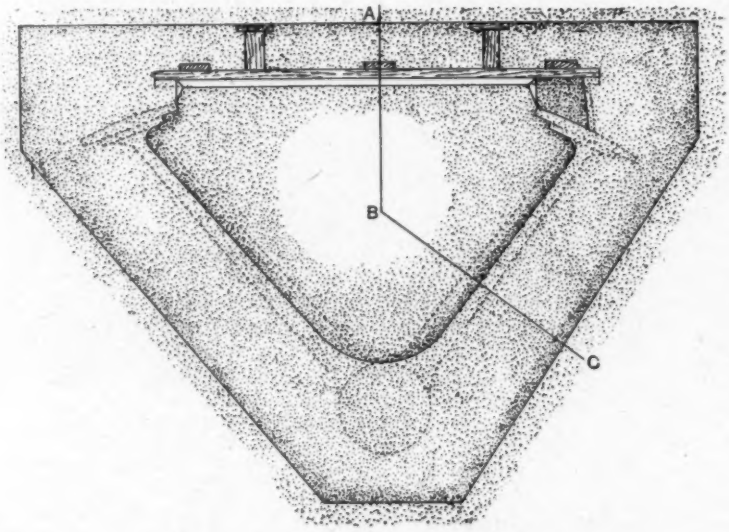

FIG. 1.
PREPARING BEDS TO FORM DRAWBACK IN CENTRE.

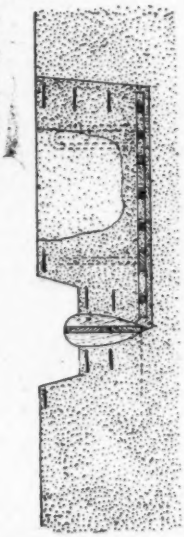

FIG. 2.
SECTION A.B.C. WITH DRAWBACK RAMMED UP.

sufficient to allow the shaft boss to project a small amount above the floor when the arms are resting on the prepared bed. This bed should be perfectly level and an impression made upon it by lowering the pattern in order to ease out the sand from about the palms and boss to allow the arms to come into contact with the bed. When the correct depth has been secured and the sand made up to the boss and palms, the positions of the arms upon the bed can be defined, and on the removal of the pattern a recess can be made to form a print for the drawback. The level of this recess can be carried out to the side of the hole dug in the floor, and around one palm where a small drawback is required to be made for convenience of access to the mould for the projecting rib. The position of this drawback is shown clearly in Fig. 1. When the pattern is replaced, a board can be set up, as shown in Fig. 1, to form the joint of the main drawback, and pre-

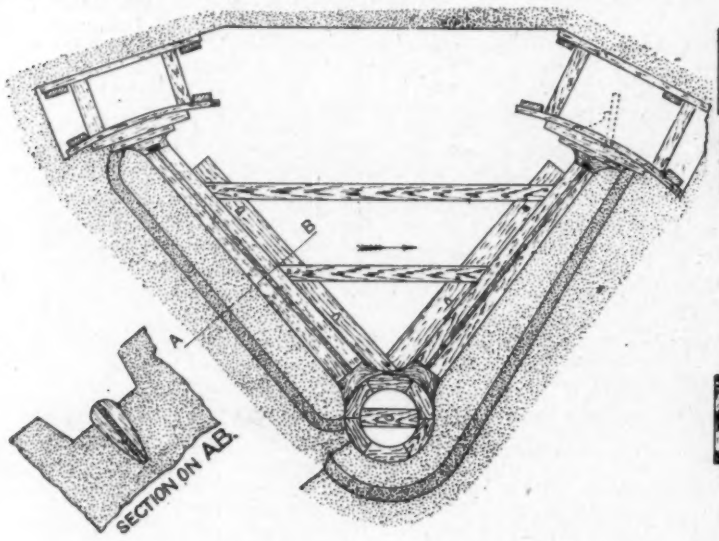

FIG. 3.—BEDDING IN THE PATTERN.

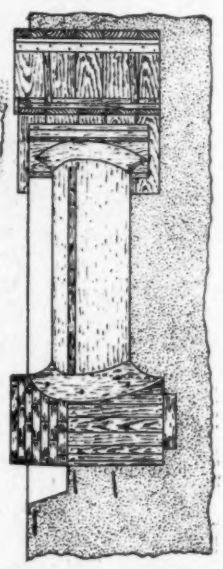

FIG. 4.—SHOWING POSITION OF PATTERN AND JOINT.

paration made to ram up the mould, leaving the faces of the palms and the back of the drawback until last, or with the temporary bracket support fixed to maintain the arms in their correct relative position, the whole of the outside may be rammed up and the joints prepared for both drawbacks. A grid is necessary for each of these, and care must be exercised in the design of the main one in particular, in order that necessary allowance be made for the contraction of the casting. When ramming up both inside and outside of this bracket, owing to the depth, it is advisable to strengthen the sand by ramming in pieces of iron at right angles to the pattern and about ½-in. from it; these set from 4 in. to 6 in. apart and in planes such as are shown in Fig. 2, will give considerable support to the sand. Then, with the palms having a considerable area projecting beyond the arms, some arrangement must be made to allow the mould to give to the force exerted by the casting when cooling. The contraction being about 3-16 in. to the foot in work of this character, and the approximate length of the arms being 11 and 12 ft. respectively, the length of the arms would contract from that of the pattern about 2 in. and 2¼ in., providing the requisite freedom were allowed for in the construction of the mould. To proceed without making any provision for easing in this instance would be fatal to the resulting casting, even though the moulder departed from the mistaken practice, sometimes adopted, of making the mould like a solid mass of concrete, and formed a shell of sand as dense as the mould, backed more loosely with floor sand; such a mould would not give to the extent required. A very good method of making provision for easing, and one which gives little difficulty to the moulder, is to ram up an old chain with the sand just behind the palms, beginning at the bottom and working in sections of chain no longer fit for other purposes, ramming up with sand the while, until the chains are thoroughly interwoven with sand over the full area behind the palms and around the arms. Leave the last link of each section accessible at the joint, so that a contact may be made through the cope box, in order to secure it to a crane for withdrawal. This is a simple device for loosening the sand at any part of the mould where it is desirable to relieve the casting.

In the construction of patterns for work of this kind, contraction allowance is frequently made between the palms. This is not usually necessary; the ordinary standard measurement will generally suffice, because there is a tendency for the arms to open rather than close while cooling, depending very much on the rate of cooling at the boss.

The alternative method of preparing the mould having drawbacks against each palm is preferable. It is advisable to prepare a bed in a manner similar to that of the previous method, and the bracket shown in Fig. 3 should be firmly screwed up to fix

the arms in their relative positions. Joints must be formed for the drawbacks, and considerable taper can be given to the sides, excepting those which come into contact with the palms. The joints at the back of these may be made after the pit is dug, and the position of the pattern has been decided by trial. Bed the pattern in, so that the arms rest upon the prepared bed, and begin to ram up around the boss, removing screws from the fillet so that the withdrawal of the pattern may be facilitated. While ramming up, it is advisable to set in rows of pieces of iron beginning about every 10 in. from the bottom, to bind the sand. Ram up both sides until the pattern is firmly fixed in position, then prepare to form the joints for the drawbacks against the faces of the palms. A thin flexible board can be made to follow the contour of the faces, since the arc is usually very flat. This can be done by using boards as in Figs. 3 and 4, one being set up against the prepared joint in each case, and the other being stayed up from it against the face. Sometimes a rough box is knocked together just to form the shape of the drawback, this being rammed about to the joint of the mould, when it can be withdrawn and used for the other drawback. As soon as the pattern is firmly held, the bracket between the arms can be removed, and the job finally rammed up. The moulder must exercise care in removing all screws likely to interfere with the clean withdrawal of the pattern.

It is necessary at this juncture to form the joint of the mould. Two methods of satisfactorily accomplishing this are shown in Fig. 3. When the pattern for the barrel is made in one length, then the joint may be dropped to the largest part of the arms, and carried against the boss, as shown, in order to strip the fillet. If, however, the boss pattern is jointed in a line with the thickest part of the arms, then the joint of the mould may be carried round on the same level as shown in Figs. 3 and 4. The section through A B shows the drop joint, a good flat bearance being necessary with a considerable taper on the sides. Fig. 4 and a section A B of Fig. 3 also show the approximate positions when layers of scrap iron should be inserted.

The projecting rib and one of the palms having been removed while preparing for the drawbacks can now be replaced and supported by two temporary brackets. One drawback would suffice against this palm, but seeing that it would be awkward to sleek off the mould as well as difficult to paint satisfactorily, it is preferable to make two drawbacks of this side, forming a joint at the extreme point of the projecting rib. Plates having staples cast into them, as shown in Fig. 5, will suffice for carrying the drawbacks. Proceed to form the drawbacks after the sides have been well coated with parting sand, by layering the bottoms with composite and bedding in the lifting plates. It is better to ram up the drawback behind the projecting rib first, so that the use of the brackets may be retained until its correct position is determined. When this is accomplished, the brackets may be removed and the rib allowed to rest flat against the drawback formed. With all drawbacks rammed up and the joint made up to the top of the palms, preparation should be made for covering. The recessed portion of the joint can be carried satisfactorily by means of grids fastened to the top box, and Figs 6 and 7 show the form of grids which would fulfil requirements. In Fig. 6 two grids are connected with a number of semi-circular pieces of iron; being cast into the side grids they form a support to the sand surrounding the top of the arms. Two such grids will carry the

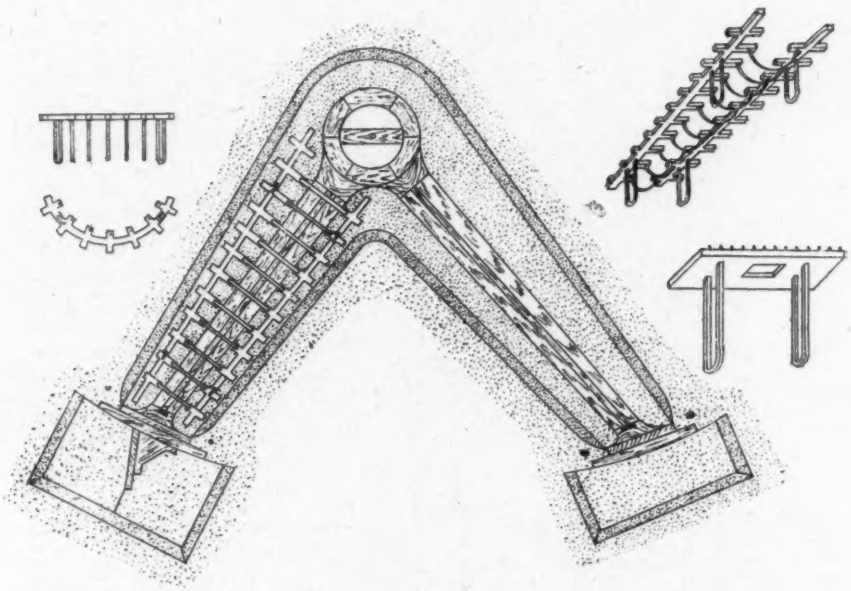

FIG. 5.—CONVENIENT FORM OF GRID FOR DRAWBACKS.
FIG. 6.—SUITABLE COVER GRID.

FIG. 8.—PREPARATION FOR DRAWBACKS FIG. 7.—GRID AT BOSS

cope over the arms, and the small grid shown in Fig. 7 will suffice to connect the two about the boss. Fig. 8 illustrates the general formation of the joint and gives the position of the drawbacks. One of the main grids is shown in position, and it

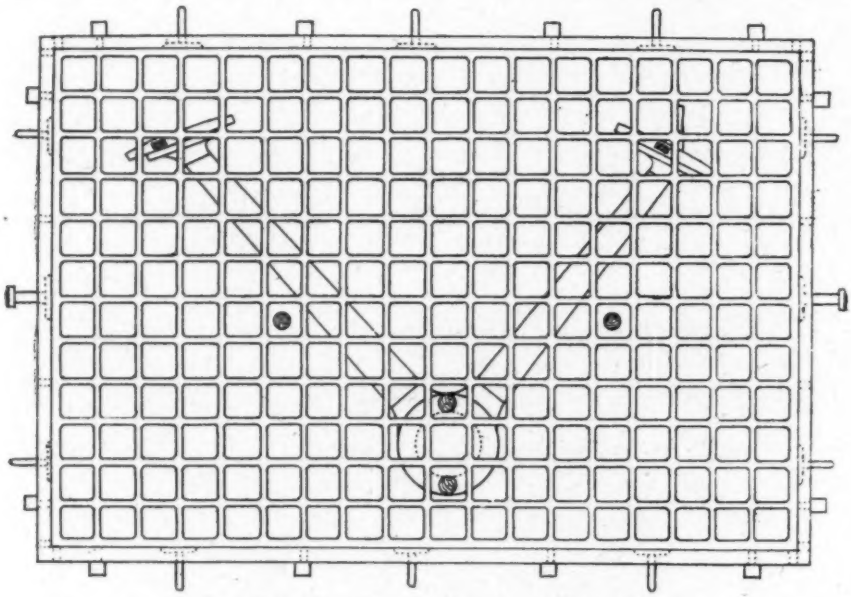

FIG. 9.—COVER BOX SHOWING RUNNER AND RISER GATES.

will be noted that the staples are cast in for convenience in fastening to the cope box.

In large steel foundries where ships' castings are frequently made, a few large cope boxes are usually stocked, capable, when the occasion arises, of dealing with very large work, but that does not prevent their being used for work well within their capacity. Providing floor space will allow, they can be used efficiently by ramming up only

the amount which will give a sufficient covering for the mould. The size of these large cope boxes is usually governed by the crane capacity, but it is only on rare occasions that the full use of such a large cover box is called for. In those foundries where the melting capacity is sufficient to deal with fairly large work, but, having specialised in a smaller class of work, have not the equipment to deal with large cope boxes, the plan illustrated

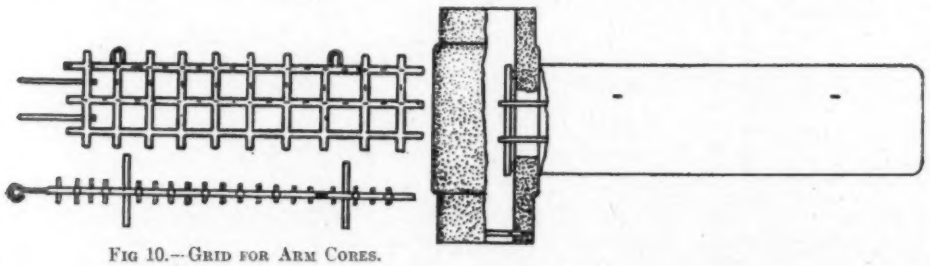

FIG 10.—GRID FOR ARM CORES.

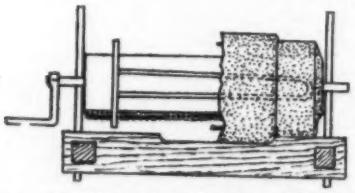

FIG. 11.—METHOD OF FIXING THE CORES.

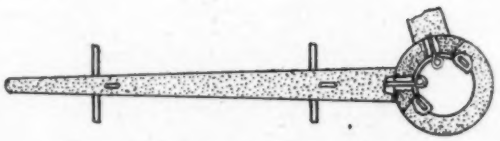

FIG. 12.—PREPARATION OF BARREL CORES.

in a previous article* in this series whereby a number of boxes are used would be adopted in this instance. Three cover boxes would be used carrying joints over the arms and near the boss,

* March issue, page 157.

but the grids would need re-arrangement so that three separate lifts could be made. The general method of carrying the top would follow the lines indicated. It is better if the work can proceed without the delay of making special arrangements for a number of cover boxes. One form of cope box frequently stocked is shown in Fig. 9. In some foundries work of this character is moulded inside of a large box bedded into the foundry floor, and the top flange is usually serrated with a number of slot holes, the cope box being similarly made, so that they will coincide with the drag box and provide a good means of securing the two when casting. In Fig. 9 the positions of the gates and risers are shown, the risers being brought off the palms and the boss. Sometimes brackets of this kind are supplied with metal by way of the boss, and spray runners to the arms are used to supplement the supply of metal, but the two gates shown supplying a spray can be formed to convey all the metal necessary, and two risers can then be drawn from the boss.

Before the cope box is placed in position, bed the grids into a layer of composite. Lower the cover box and secure the grids, set the runners and risers and proceed to ram up. Bits of piping should be placed over the ends of the chain sections, rammed up at the back of the palms, in order to render them accessible when the job is finally closed.

While the cope is being formed, the preparation of the cores will receive special consideration. A simple grid suitable for the arm cores is shown in Fig. 10, a number of pieces of wrought iron being cast in to give greater support to the sand. At two places, and on an approximate line with the joint of the mould, two large pieces of iron are cast in the grid, projecting at each side far enough to penetrate the metal space and have a sufficient bearance upon the joint of the mould to provide some support to the core when setting it in its position. Two staples are cast in for lifting purposes, and a couple of eye-bolts project from the end of the grid far enough to pass into the centre of the boss core. There are a number of methods of stiffening the arm cores, but as the only means of access after the job is cast, is by way of the boss, a simple form of grid should be used so that the cleaning of the casting may be easily accomplished. The central portion of these arm cores should be filled with ashes, but the skin, and to a depth of about 3 in., should be sound and strong.

When the foundry patternshop prepares the work, a mutual understanding exists between the patternmaker and the foundryman, and considerable saving is frequently effected by increasing the work or reducing it for any given job in either department. Because of this mutual understanding, the foundryman will often use, and have success with the pattern work supplied by the patternshop attached to the foundry, frequently managing with methods that would not be tolerated from outside patternshops. When the departments are combined, the methods usually resorted to are the cheapest which will secure a sound casting with the minimum expense in the patternshop. Thus, in providing pattern work for the boss core, a half-box would be required from an outside firm, the top half of the core being worked off with a strickle. In this way prints would be inserted in the box for locating the positions of the arm cores. Such a method increases the cost in the patternshop and does not reduce the work in the foundry to an extent commen-

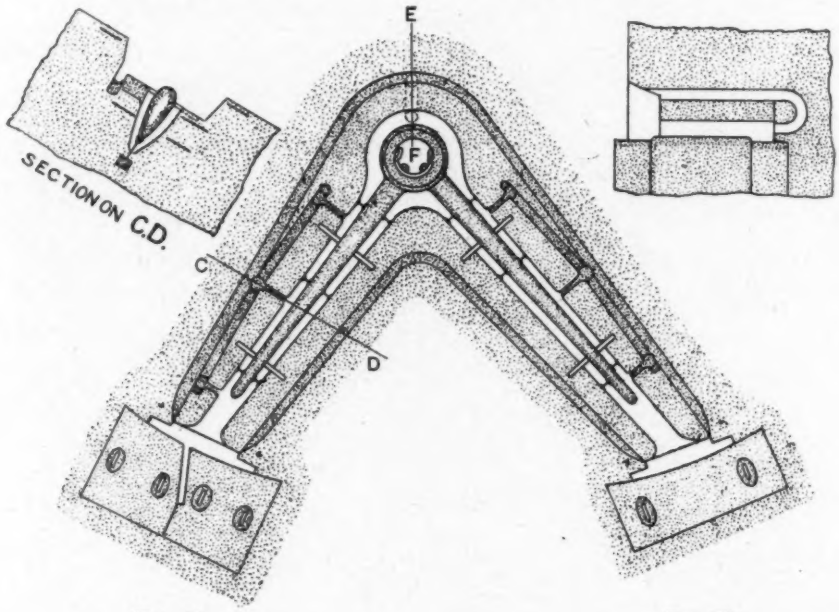

FIG. 14.
CORES SET READY FOR CLOSING.

FIG. 13.
SECTION ON E.F. SHOW ADDITIONAL RUNNER.

surate with the time taken to provide a core box. Hence, while a core box would be expected from an outside firm, the foundry patternshop would provide a sweeping board for the boss core. Usually in preparing cores of this kind, straw rope is worked about a horizontal spindle to within about 4 in. of the sweeping board, as shown in Fig. 11. Over the straw rope, and at each end of the spindle, a couple of circular grids are fixed, one having a couple of long staples cast in. Long pieces of iron are firmly screwed to each grid, forming a cage, which gives the necessary strength to the core. Stiff composite is worked in against the straw rope surrounding the grid and a core roughly turned up to within 1¼ in. of the finished diameter. The core is then dried sufficiently to take the final coat of composite, which can be thinned down to give a better finish. When the cores are thoroughly dried, they should be coated with well boiled tar, and again stoved till the tar is quite dry.

The cope box having been sufficiently rammed to provide the necessary amount of covering, and the gates and risers withdrawn, may be rolled over and the withdrawal of the pattern commenced. Proceed to withdraw the boss from the drag, and as it is on an angle with the arms, a certain amount of care in the process is essential. Draw the fillets into the mould of the boss, and thus clear the arms. The arms should not offer much resistance, but screw eyes should be firmly fixed into them for convenience in handling. When these are removed, the drawbacks may be withdrawn, which leaves the palms practically free for lifting out. The runners require to be prepared and the whole mould carefully sleeked over. A method of forming the spray runners is shown in Fig. 14, the approximate size of each inlet being 5 in. × 1¼ in. A special mixture of composite is preferable for making up runners, because the refractory nature of the sand must be maintained during the time of pouring. The method of supplying metal to the boss, sometimes adopted, is shown in Fig. 13, which is a section on E F of Fig. 14. Special steel runners are usually inserted when such a method is adopted. When the mould is well sleeked over, sharp corners worked off, excepting around the palms where the corners are required to be squared, and the joint of the mould compressed to cause a fin in the casting, the whole should be dried. The cope having been treated in a like manner can be supported over the mould, and box fires or patent mould driers used, the heat being retained as much as possible by sealing the sides with iron plates. When the mould is dry, apply a coating of tar and again thoroughly dry. Sometimes only the mould about the boss is coated with tar, the arms being coated with silica paint. In heavy castings, however, well boiled tar is by far the best means of providing a good skin to the casting.

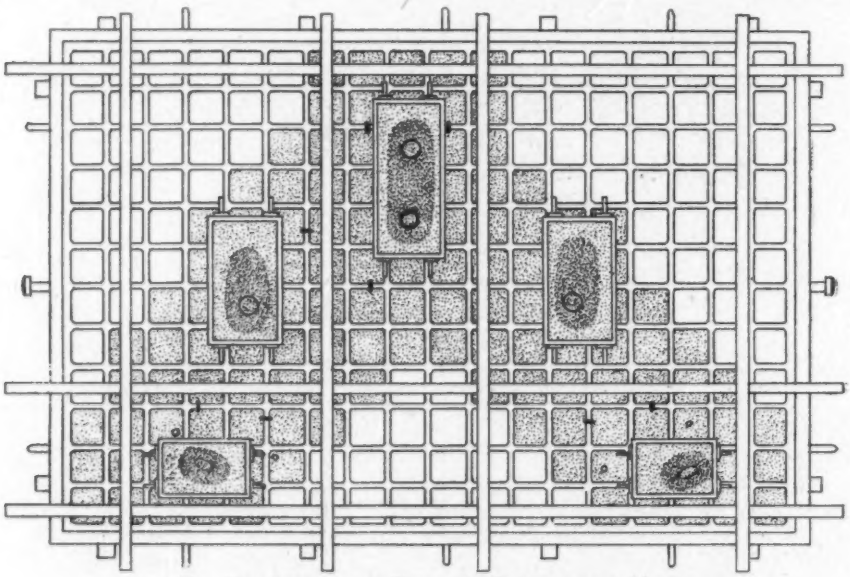

FIG. 15.—COVERED AND READY FOR RECEIVING THE METAL.

Both mould and cores being ready, proceed to assemble preparatory to casting. Lower the boss core in position, and locate the approximate position of the arm cores. Withdraw the centre core, and proceed to cut a clearance as vents for the arm cores, and to allow the eye-bolts to pass through the wall of the core. Sink a couple of specially prepared chaplet blocks into the bottom of each of the arms, as shown in section C D in Fig. 14, and again place the centre core in position. Set the arm cores in their relative positions, easing out the sand on the joint to allow the irons cast in the grid to find a bearance when the cores are resting on the chaplets. Make a good butt joint between the cores and wedge up inside the centre core. If these cores are carefully handled they can be lifted as one, and composite grouted in where they join, and a small fillet formed. This must be thoroughly dried and coated with tar.

Nail a few chaplets to the sides of the mould, as shown in Fig. 14, and replace the cores when the job can be closed.

Clean the runner and riser gates, rub off any sharp corners likely to give way while the metal is passing through, and lower the cope into its position, using clay for testing the thickness over the arms. Try the runners and risers with chalk to ensure that their relative positions are maintained, and then lift the top box for inspection. Set a few chaplets on the arm cores, their thickness coinciding with the thickness of clay, and to ensure against the possibility of metal finding entrance to the inside of the centre core, make a clay contact, oiling it well before finally lowering the cope. Attach hooks to the ends of the chain sections, so that they can be easily secured to a crane when required to ease the casting.

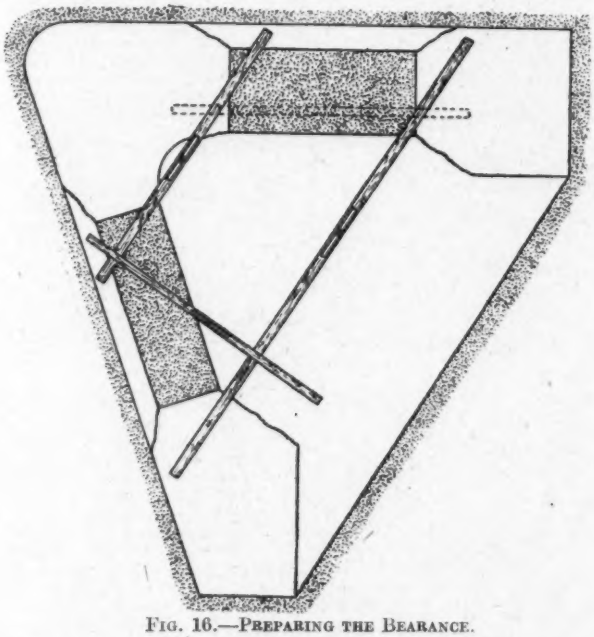

FIG. 16.—PREPARING THE BEARANCE.

The job may now be weighted and bolted preparatory to casting, and the runner and riser basin made; a general idea of the arrangement being as illustrated in Fig. 15. It will be noted that only sufficient of the top box is used to provide the necessary covering. Two ladles of metal are necessary in pouring the job, and stoppers are withdrawn simultaneously. It is advisable to feed the casting by way of the risers as long as the metal remains in a liquid condition. Within a little time of the cessation of feeding, withdraw the chains and allow the casting to cool.

Castings of this description, because of their important position with regard to the propulsion of the ship, must be of a reliable character, hence every care must be exercised in thoroughly annealing all such castings. Providing the annealing furnace is prepared, and its temperature is approximate to that of the casting when it is put in, the casting may be transferred from the foundry floor to the furnace while it is still warm.

Bracket No. II.

While the moulding of this propeller bracket does not differ essentially from the previous one, yet many of the details and methods of applying the principles vary the construction of the mould. It is rarely indeed that large numbers of castings of this description are made to one design, the opinion held by designers as to the relative merits of the means of securing the bracket to the frame of the ship, to give that rigidity and strength desirable to such an important part of the ship construction, and the varying shape of the fishbacks or arms, to render the resistance to the progress of the vessel as small as possible, naturally leads to considerable variation. The

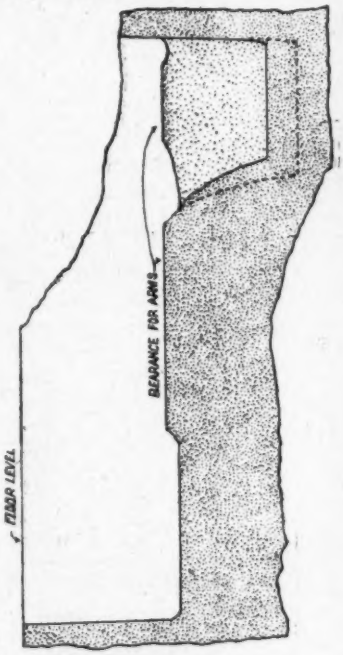

FIG. 17.—SECTION SHOWING BEARANCES AND FORMATION OF PIT IN FOUNDRY FLOOR.

length of the boss, too, requires special consideration. In very fast vessels, such as torpedo craft, cruisers or mail and passenger ships, the boss is more lengthy than in ordinary merchant vessels. These factors of palms, fishbacks and bosses enter largely into the relative advantages and disadvantages of the various means of moulding this type of propeller bracket, almost every job requires special initiative and resourcefulness in scheming the construction of the mould, while maintaining the principles governing the formation of moulds for steel castings. It will be noticed that the direction of each of the palms, the vertical centre of the arms, and the centre line of the boss vary; they are not in planes parallel to each other in any case, and it would be a remarkable coincidence if it ever occurred. These naturally increase the difficulties with which the moulder is confronted, and necessitate the ability to determine the best means of obtaining a sound casting, true to shape, governed by the material and equipment at his disposal, in any given circumstances. In some steel foundries large boxes are set into the foundry floor, merely forming a framework to which the top box can be screwed.

Though this confines the size of work capable of being moulded in it to the surface area at the joint, it allows any depth being used to meet the requirements of any individual job. This method has considerable advantages when the character of the work prevents the successful use of the rolling over of the drag. It is, however, only in the large steel foundries which specialise in this particular class of work that provision is made in such a manner for taking large work, as in other foundries, where such work is only obtained occasionally, it is not considered to be economical to occupy large spaces in the foundry floor with such boxes, even

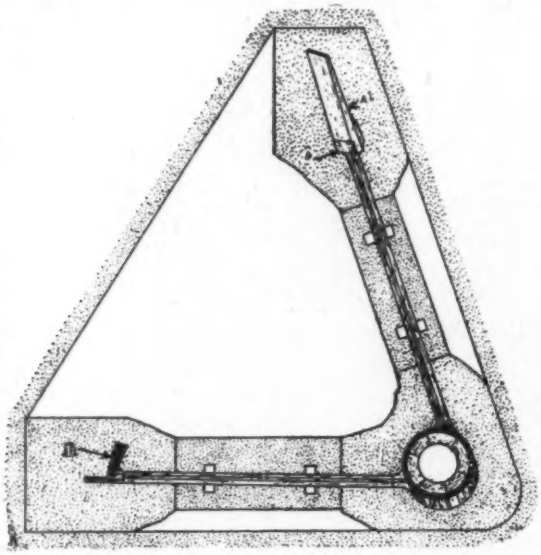

FIG. 18.—PATTERN IN POSITION ON BEARANCES.

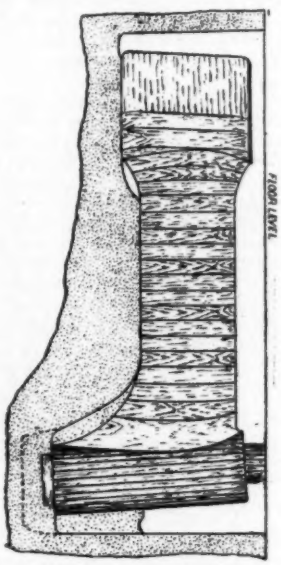

FIG. 19.—SECTION SHOWING BEARANCES MADE UP FOR PALMS AND BOSS.

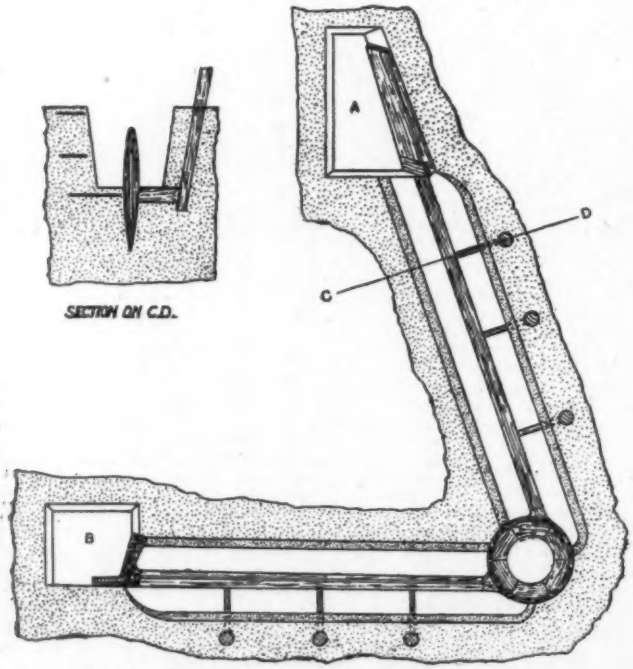

FIG. 20.—BOTTOM RAMMED UP AND JOINT FORMED.

FIG. 21.—TYPE OF PLATES SUITABLE FOR CARRYING DRAWBACKS FOR PALMS.

though smaller work could be very well prepared in them. Hence, when large work of a character similar to a propeller bracket is required to be undertaken in such foundries, the floor is just used for the drag, and the cope box set upon the levelled floor. As this method offers no facilities for holding down when casting, sufficient weights must be lowered on the cover box to give the necessary resistance against any tendency to lift.

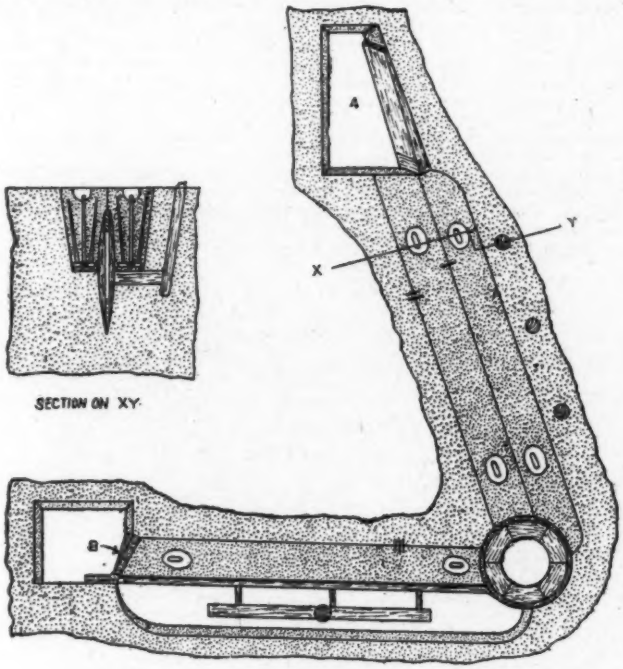

FIG. 22.—SHOWING DRAWBACKS FOR COVERING ARMS.

In considering the preparation of the mould for this bracket, the method frequently adopted is similar, whether the drag box is available in the foundry floor or not, as it is necessary to make up the major portion of the mould in the floor. Bedding-in in the ordinary way is not desirable because of the difficulty in handling such a pattern, and also in maintaining its rigidity. Hence bearances are required to be formed at a depth below the surface of the floor, which will reduce to a minimum the amount of top lift for any part. In this instance the pattern should be rammed up with the top of the boss flush with the foundry floor. The bearances most convenient to make are those for the fish-backs to rest upon, since they are in the same plane. The illustrations Figs. 16 and 17 show the shape of the pit to be cut out of the sand, and its depth to accommodate the pattern. A method for preparing the bearances is shown in Fig. 16. When these bearances are formed they can be used as a guide for determining the depth of positions for the palms and boss. It is not possible to make these up exactly before setting in the pattern, because of the bevels, but an approximate bearance can be made with the sand softened in order that an impression may be taken when the pattern is lowered in. Figs. 18 and 19 show the pattern set in position upon the bearances, bits of flat iron being laid upon them to prevent the pattern bedding itself in. The bearance for each palm should be levelled off large enough to form drawbacks, which are necessary for the successful removal of the pattern, and for free access to the mould after the pattern is removed. When setting large patterns of this type, instead of lowering them in complete, they are frequently assembled in the pit; but in any case, whether this plan is adopted or not, the presence of a pattern-maker or a representative from the mould loft is desirable to make final measurements to ensure as far as possible the correct relation between the various parts comprising the pattern before ramming is commenced. When the pattern has been set, it can be fixed with battens and supports set up for forming the joints of the drawbacks. The thickest part of the arms should be marked to

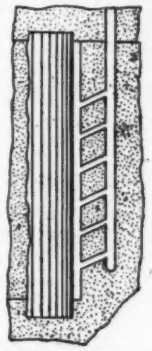

FIG. 23.—FORM OF RUNNER WHEN BOSS IS VERY LONG.

FIG. 24.—GRID FOR ARM DRAWBACKS.

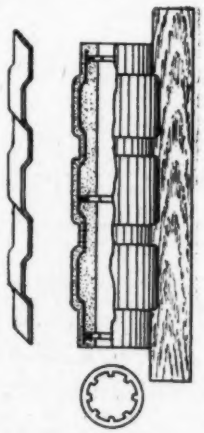

FIG. 25.—PREPARING THE CORE.

give a guide in forming the joint of the mould, and then ramming can be commenced. It is best to ram up about the arms a little way first, to give further support to the pattern and prevent the possibility of any movement due to the force of ramming at any one place. At the very commencement, however, consideration must be given to the shrinkage of metal forming the casting. The arm carrying the palm A Fig. 18 offers no special difficulty, and no provision need be made, because the small shoulder is graduated by the large fillet B connecting the palm with the arm. The shape and greater length of the palm B is quite different, and is liable to become mis-shapen and badly strained, or even broken, unless some special means are adopted to allow shrinkage to take place, with as little resistance as is practicable. To meet the requirements, a chain is frequently rammed up with the sand immediately behind the palm, and covering a depth of about 12 in., being worked round the joint and carried to the surface of the mould in a similar manner to that

sure of the metal while the mould is being filled. The ramming of the mould can be carried on, making provision for the shrinkage of the casting using about 1½ to 2 in. of composite against the pattern, and stiffening the sides near to the pattern with irons or gaggers at a convenient distance from the bottom, as shown in the section CD of Fig. 20. It will be noticed that the thickest part of the arms is a little more than half of their depth, and it is along the guide lines marked at this part that the joint requires to be made. Runners should be bedded in after the bearance for the joint has been sleeked over and connecting-gate sticks set, when the remainder of the drag-mould can be rammed up, leaving sufficient room to give body to the cover.

The method of running the job varies according to the general design of the bracket, but in general practice, when the boss is not very much deeper than the arms, and the connection between them a gradually changing shape, the metal is supplied by way of the

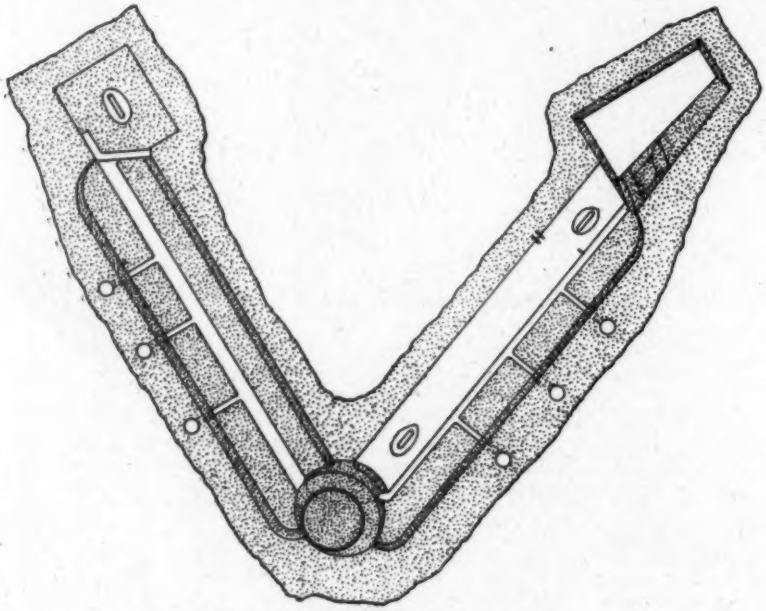

FIG. 26.—MOULD BEING ASSEMBLED.

explained in the previous article. While this method is quite successful in many instances, when the disturbance of the sand near the place where the greatest resistance will be given, is sufficient to weaken the mould, in this bracket the area of the mould forming the resistance is too great to adopt that method alone, but if used in conjunction with a specially prepared body of weak sand a good result will follow. The sand is weakened by the inclusion of a quantity of sawdust and used as a backing to the composite, which should be about 2 in. in thickness at the place where this weak sand is used. It is rammed up near the sand carrying the chain, so that after the job is cast and the chain withdrawn to loosen the sand, the heat having carbonised, the sawdust allows the displacement of the mould, and the shrinkage takes place without any serious influence upon the casting. A good backing of cinders fulfils a similar purpose, and is frequently used; but whatever method is adopted, must weaken the back sufficiently to allow for the shrinkage and contraction of the casting without interfering with the capacity of the mould for withstanding the pres-

arms as shown in Fig. 20. When, however, the boss is very long, it is better to supply metal to the boss direct, and for this purpose a gate connected with a series of runners in the form of a spray is very suitable, as indicated in Fig. 23. It is not necessary that these runners should be delivering metal all together, the idea being that hot metal can be supplied to the top, rather than being forced up from the bottom; therefore the runners forming the spray should have a greater area in the aggregate than the gate. When a quantity of metal has been poured, depending upon the depth of the boss below the arms, an additional supply of metal should be provided by way of the arms, so that the temperature may be maintained. In Fig. 20, the gates are independent of each other, being connected afterwards by the feeding trough or basin. When this method is adopted, considerable difficulty is often experienced in setting them to clear the bars in the cover box. To overcome this, the recess forming the joint is sometimes made wider on the outside of the arms, to make room for a connection between the runners, so that one gate to each arm will suffice, as

illustrated in Fig. 22. Having worked up the joint to the surface of the mould, as shown in Fig. 20, the drawbacks for the palms can be rammed up. Two plates are shown in Fig. 21 which are suitable for carrying the drawbacks, that for carrying the drawback A, having a number of prods cast with the plate and lowered in on to a bed of composite. The plate for drawback B shows four iron bars cast in at the corners. These serve as a support for loose pieces of grid to which they can be wired, the pieces being fixed in as the process of ramming proceeds. It is necessary to loosen the pattern during the time of ramming, and take all precautions to facilitate its removal from the sand. All screws holding loose pieces should be removed. It saves the moulder much time if cheese-head screws are used for these loose pieces, and the heads left above the surface of the pattern. Owing to the depth of the lift over the top of the arms, it is not good practice to attempt to carry it with the cope; it is preferable to cover them separately; and make up a surface for the top box level with the top of the palm B and dropped to leave the edge of the palm A and the surface of the boss so that these can be carried in the top box. As illustrated in Fig. 22, the covers or drawbacks for the arms are divided in a line with the vertical centres of the arms for convenience, but with shallower lifts they can be made in one piece over each arm. A suitable grid for carrying each of these drawbacks is shown in Fig. 24. Grids of this type bedded into a covering of composite, allow free access to the top for ramming up the drawbacks. The drawbacks directly behind the palm B require very careful manipulation, as although it should be strong enough to permit a lift without risk, it should be so constructed that it will crush under the strain of contraction without materially affecting the casting. The grid should allow ample clearance, and ashes should be used to weaken the drawback. Thin webs are sometimes cast on, connecting the palm with the arm in such instances, because the metal forming the palm is considerably lighter in section than the arm, and will naturally solidify more quickly. Hence the shrinkage of the metal in the arm being later in its action, tends to cause a bending action at the junction between the two, and the casting becomes distorted. These webs offer a resistance to this action, and are much favoured by steel moulders. If, however, the mould forming the back of this palm is sufficiently weak to give under the strain, the webs may be neglected.

When these drawbacks have been formed and the joint made up, a plain box may be lowered over, large enough to take the cope. The type shown in Figs. 27 and 28 is usually of a standard nature for work of this class, and is suitable for various shapes. Only that part of the box covering the job need be rammed. Risers should be set on each palm, and two or three on the top of the boss, and since there is a drop to the surface of the boss and the palm A, gaggers should be freely used to ensure a good lift.

After successfully ramming up the top box, the work of dissembling the mould can be commenced. The cope box is removed and the pattern of the boss is withdrawn, then the drawbacks, which should have distinguishing marks made upon them, are lifted out. In withdrawing the remainder of the pattern, the moulder, having paid particular attention to the method of construction, will draw the palm B into the opening left by its drawbacks, and then out of the mould altogether. The fillets connecting the arms with the boss will be withdrawn in a similar manner. The smaller loose pieces attached to palm A having been lifted into its drawback, both arms can be withdrawn without further delay. The surface of the mould should be well sleeked over, the runners made clear and sharp corners eased off, the whole mould being dried.

The shaft core can be satisfactorily swept up on a horizontal spindle, and the spindle afterwards removed. The requisite stiffening to the core is given by three cast-iron rings, to which are wired a number of pieces of iron shaped to suit the profile of the core, as shown in Fig. 25. These pieces of iron are bedded into the composite forming the core, until they come into contact with the grids, when they are secured, and the core revolved against the board for final sweeping.

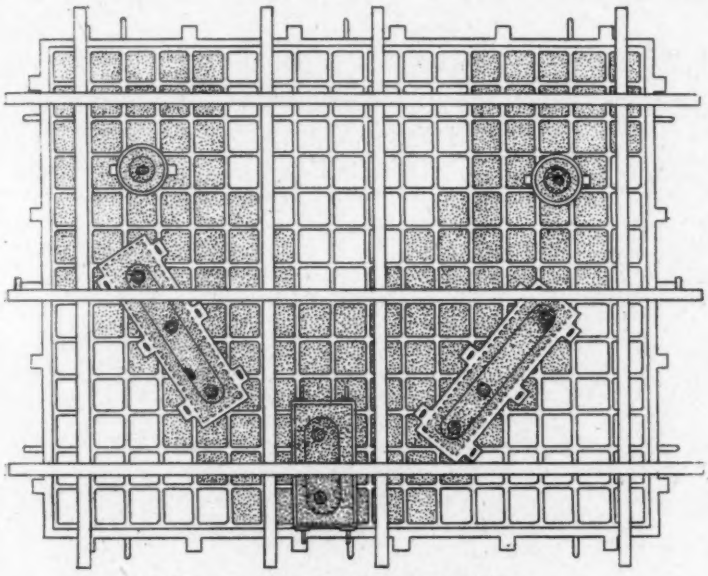

FIG. 27.—READY TO RECEIVE THE METAL.

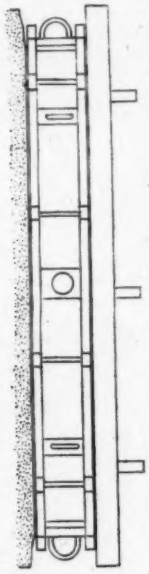

FIG. 28.—END OF SUITABLE COPE BOX WITH A DRAG BOX BEDDED INTO FOUNDRY FLOOR.

When the mould drawbacks and core are thoroughly dried they should be painted. After having carefully examined the mould and filled in any cracks which may be present, the whole should be finally dried. The work of assembling the mould will take considerable time, and care must be exercised in getting the various pieces in their correct relative positions. Fig. 26 gives a general view of the finished mould.

About the fillets and along the thicker portion of the arms, nails are frequently knocked into the sand, leaving a large part of them projecting into the mould. These assist in solidifying the metal more regularly and prevent the tendency to draw upon the thicker parts of the casting. When the job is assembled and the cover box lowered, gate and riser head are prepared, dried and coated with tar, and grouted into their relative positions on the cover box, as shown in Fig. 27, and preparation made for casting by securing against a possible lift. The illustrations Figs. 27 and 28 show a method used when the job is cast in the foundry floor without a drag box. If a box is bedded in the floor, then bolts and clamps can be used together with

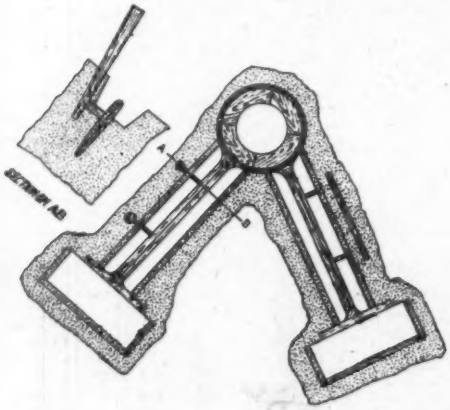

FIG. 29.—METHOD OF MOULDING SMALLER BRACKETS.

the iron beams shown. After the metal has been cast, feeding should be resorted to by way of the risers, and easing should commence as soon as the metal is in a solid state. Owing to the importance of this type of casting in its relation to the motive power of the ship, considerable care must be exercised in the annealing process in order that all possible strain may be eliminated.

The small bracket which is attached nearer to the hull of the ship, being very near to the entrance of the propeller shaft to the shell, is usually of the type shown. The arms are of the fishback design, and the method of moulding is similar to the foregoing example. The varying angles of boss and palms raise difficulties in the successful removal of the pattern. Fig. 29 shows the general practice in forming the joint in such instances. When the depth of the arm from the joint is too great for convenience in successfully sleeking up the mould, then the central portion between the arms is lifted as a drawback; but whenever possible, the method illustrated is adopted, because less time is occupied on the work. The general casting arrangement is shown in Fig. 30, which shows three risers of the boss, two of these assist in feeding the junction between the arms and the boss, and are largely responsible for preventing sponginess of metal at this part. The same remarks respecting easing and afterwards annealing are applicable in this instance.

Compulsory Continued Education.

An Education Committee was set up by the late Executive Council of the Federation of British Industries, on the recommendation of the Commercial Efficiency Committee, in order to consider certain grades of national education which have particular bearing on industrial progress. It was decided that compulsory continued education under the Fisher Scheme should be considered in the first place, and the Committee have framed and issued a report, in order to bring to the notice of manufacturers the problems connected with the scheme, and to offer suggestions for the solving of the same. Two of the chief points on which advice would be asked are the allocation of hours for continued education, and the framing of a curriculum, both of which are dealt with in the Committee's report.

In conclusion, the following general recommendations are made :—

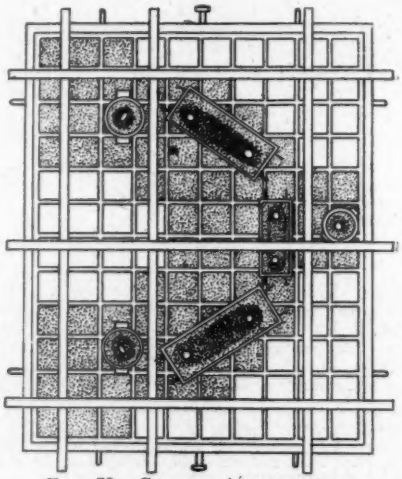

FIG. 30.—CASTING ARRANGEMENT.

(1) That the classes, except in exceptional circumstances, should be held on two half-days, or on one whole day per week, the former for preference.

(2) That the curriculum in the first place should be of a general educational nature, with due regard to the value of vocational illustrations. There should be in the later stages a development of those subjects which bear most closely on the actual work of the young people, in order to effect the balance between their craftsmanship and their theoretical knowledge and general outlook. In deciding the curriculum an advisory committee of educationists, employers, and employees would be of great assistance, and for this purpose branches of the National Alliance, Whitley Committees, and other joint bodies of employers and employed should be used whenever possible.

(3) The teachers should be of broad understanding, and facilities should be given to them so that they may have a sound general knowledge of the local industries.

(4) Firms should help to meet the young employee's loss of wages consequent upon his attending educational courses, but this should be dependent upon satisfactory efforts being made by the pupils to make the most of their educational courses.

(5) The main lines of co-operation have been enumerated, and there is little doubt that the provision of scholarships, payment of fees, etc., will be maintained.

The Electrode Company of Sheffield, Limited.

Prior to the war, practically the whole of the electrodes required for duty in electric furnaces were imported from Germany, Sweden, and possibly the best from America. The consumption of electrodes, however, at this time was not sufficient to justify laying down a works solely for their production, because the electric furnace only seriously came into its own as the necessity arose for dealing economically and expeditiously with enormous quantities of steel turnings, and for the production on a large scale of special steels. Needless to say, the home production of electrodes was wholly unequal to the demand, and with imports from Germany and Sweden entirely suspended, and supplies from America very restricted, a serious shortage was inevitable.

To meet this shortage was the first object of the Electrode Company of Sheffield, Limited, which was formed in 1915, and has the distinction of being the first company in this country solely devoted to the manufacture of electrodes. There was no time for lengthy experiment; electrodes had to be made, and that with the least possible delay. The company, therefore, decided to assemble the best plant available and to couple with its operation research work and exhaustive practical experiments with a view to establish what cannot fail to be a very important after-war industry, for whilst a very large number of electric furnaces are already installed throughout the country, they have a possible and important field of usefulness still to be developed, *i.e.*, as refining furnaces working in conjunction with Bessemer furnaces.

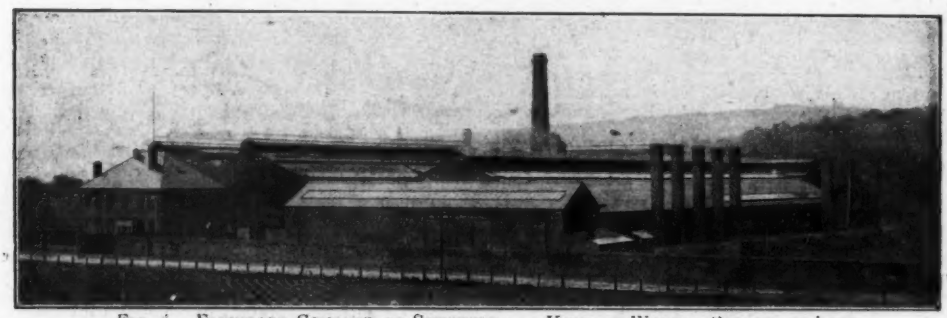

FIG. 1.—ELECTRODE COMPANY OF SHEFFIELD: VIEW OF WORKS; OFFICES ON LEFT.

The site chosen for the works was at Wincobank, near Meadow Hall Station, about 5 miles from Sheffield on the Barnsley branch of the Great Central Railway. This was the first works to be erected in the valley, since when, however, several adjacent sites have been taken over by other companies, and it seems probable that this is the direction in which the Sheffield industries will find an outlet for expansion. The site is conveniently placed for both the Great Central and Midland Railways, with the first-named of which the sidings from the works join up. A serious objection to

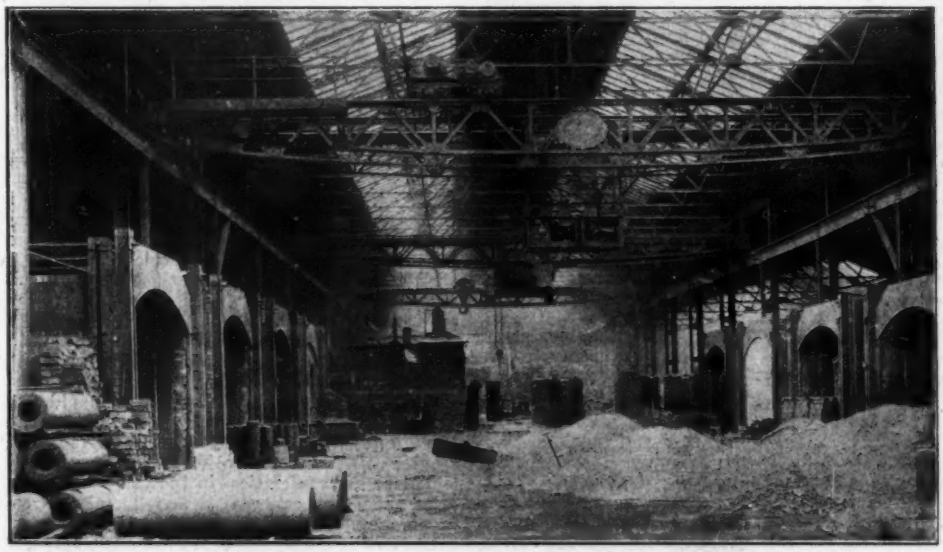

FIG. 2.—ELECTRODE COMPANY OF SHEFFIELD: VIEW OF MAIN BAY.

the site at first was that the land, lying very low, was subject to flood. To safeguard against this possibility the whole of the land was made up to a height of 7 ft., the brook which runs through it being first diverted and tunnelled over throughout the length of the property by a tunnel 11 ft. wide × 5 ft. 6 in. high.

The offices of the company—a substantial brick building—front on to Grange Mill Lane. The usual accommodation is provided for the managerial staff, as also an office and laboratory for the works manager. In this last is placed the pyrometer recorder (Cambridge Scientific Instrument Company).

The works, which are laid out solely for the production of amorphous-carbon electrodes, as at present in operation are covered by a building 320 ft. × 100 ft., the floor of which is served by three 5-ton Vaughan electric cranes. The raw material is delivered by rail direct into the rear of the works adjacent to the furnaces for burning the anthracite. These furnaces comprise a muffle-type by Wincott and a retort-type by King, Taudevin & Gregson. The calcined material is delivered to the scrap electrode and retort-carbon stocks which are disposed round the grinding plant. The rough material is first passed through a Hadfield crusher, falling from this into a below-ground hopper, from whence it is raised by a bucket elevator and delivered to a hopper feeding a Newell ball mill. The crusher is direct driven by a 20-h.p. B.T.H. motor and the ball mill and elevator, etc., by a 45-h.p. B.T.H. motor. The ground material is graded and mixed and then passed to a battery of four steam-heated runner mills (Smedley, Bros.). Each of these mills is driven from an independent countershaft belt-driven by a 45-h.p. B.T.H. motor.

The moulding pit is placed immediately at the rear of the mills. The moulds, after being first immersed in oil heated by steam coils, are filled under the ram placed above the pit, this ram being driven by a 3-h.p. motor. The filled moulds are next taken to the presses, which are lined along the opposite side of the mould pit to the mixing mills. The press plant consists of two presses of 500 tons and three of 300 tons capacity: these are hydraulically driven each direct from a separate pump, each pump being driven by a B.T.H. motor. The starting gear is also of the B.T.H. manufacture, the whole being housed together in a lock-up building.

The electrodes, threaded at both ends, are, after pressing, stripped by a further stroke of the press ram and then stood on end to dry. The screws, which are made in split moulds, are dealt with under one of the 300-ton presses, which has a specially short stroke for the duty. The dried electrodes are stoved in a battery of ten coal-fired furnaces, the complete operation of heating up, firing and cooling down taking about three weeks. From the furnaces the electrodes, after examination, are passed into stock. It will thus be seen that there is a perfect continuity of operations, the raw material being delivered to one end of the works and leaving the other as finished products. The present output of the works is approximately 2,500 tons per annum in the standard range of sizes from 12 in. to 20 in. in diameter, these last weighing about 12 cwts each.

The company are at present engaged upon some important extensions which, when completed, will enable them to bring their output up to 7,000 tons per annum. Whilst, as already stated, the first consideration of the company has been, and will continue to be, the manufacture of electrodes for electric furnaces, they will naturally develop in other directions. In the light of the experience gained with the working of the plant under notice and the costly experiments and research work undertaken during its operation, revolutionary changes are being made in the lay-out of the new works.

The new press shop, 150 ft. × 80 ft., will be served by two 5-ton Arrol cranes and equipped with five hydraulic presses (Davy Brothers, Limited) and a mixing plant, in which very material improvements have been effected. The final design of the furnaces has yet to be determined. Various types of gas-fired furnaces will be tested, so as to ascertain the type most suitable for the conditions, before putting down the complete installation.

Reducing Casting Losses.

According to a writer in a recent issue of "The Foundry," a brass foundry secured a contract for a large number of pipe flanges. These castings varied in weight from 2 to 80 lbs., and were cast from bearing metal. Much so-called bad luck was experienced. For six weeks, four experienced moulders worked on the job and did not produce as many good castings as should have been expected from one moulder. Even the castings accepted as passable were imperfect. When the metal was hot, a few good castings were produced, but if the metal was dull, all the castings poured were scrap. The main trouble was that the castings had a rough, wrinkled, seamy appearance, known in brass-shop parlance as *smoky*. The difficulty was eventually overcome by rapid pouring, the moulds being inclined at about 20 degrees, and the pouring gate placed at the lower end so that the metal had to run up hill. Only one opening was cut into the mould, and a good riser was placed directly opposite. By tilting the mould in the manner described, the riser was brought to the highest part of the mould, and, therefore, could feed the casting better. One great advantage in pouring in this manner lay in the fact that no difficulty was experienced in keeping the gate choked. Authorities on brass-foundry practice place great stress on keeping gates choked to prevent air from entering the gate. When the moulds are tilted, the gate remains choked even if pouring is irregular or ceases entirely. Furthermore, smoke has no chance to remain in the mould, as it is driven out of the riser before the advancing metal. Also fast pouring reduces to a minimum the formation of oxides on the surface of the metal inside of the mould. Much of the trouble which was termed *smokiness* was in reality cold-shut. Up-hill pouring cures that trouble even if the metal occasionally is dull. It is the writer's theory that, when pouring starts, the first metal through the gates spreads out unhampered in the wide spaces of the mould. Some of this finally stops because of friction with the sand, and some because the cold surface of the mould chills the metal, thereby rendering it sluggish. Irregularities in pouring and various other agencies cause this first metal to remain alone for a time, and when finally other metal arrives it is chilled, and often a cold-shut or misrun casting results. Whilst the delay may be almost infinitesimal, it may be enough, especially in light work, to cause serious results.

For many pieces of ornamental work, and for castings with exceptionally smooth surfaces, the up-hill method of pouring will aid materially, as metal cannot have a cutting or washing action on the face of the mould. In making matches, follow-boards, and match-plates, the patterns often can be so arranged that this method of pouring can be used by simply tilting the pattern.

Fuel Economy in Cupola Practice.*

By H. James Yates.

Fuel consumption in cupolas is found to depend on several factors. The heat developed is employed in the following manner :—(1) For melting the iron and fluxing the impurities. (2) For providing the necessary extra heat in the iron to enable it to continue sufficiently fluid to make satisfactory castings while being carried from the cupola to the moulds—often a considerable distance. (3) To make good the heat losses : (*a*) From the casing by radiation. (*b*) Due to sensible heat in the waste gases. (*c*) Undeveloped heat in the unburned carbonic oxide.

Of these, No 2 may seem unnecessary to mention apart from No. 1 because, of course, the ultimate object of all cupola melting is to obtain good castings; but it is now mentioned separately because unless it is taken into consideration a comparison of results obtained in different foundries is impossible. A foundry making light castings requires much hotter iron than one employed on heavier and rougher work. Similarly, a large foundry requires hotter iron than a small one on account of the longer transport from the cupola to the moulds. As a consequence, the fuel expenditure per ton of iron melted is bound to be more for the light castings than for the heavy, and more in the case of the large foundry than the small one. As an example of this, a foundry making both light and heavy castings gave some years ago figures per ton of iron melted as 2 cwt. 2 qr. 4½ lbs. coke for the light, and 2 cwt. of coke for the heavy casting. It will be most convenient to deal first of all with No. 3.

(*a*) *Loss by Radiation.*—As the ratio surface to capacity diminishes with increasing diameter, it is advantageous to build wide cupolas, except in so far as the diameter is limited by considerations of blast penetration and is determined with a due regard to the diameter; height mentioned below. This loss by radiation is of small importance compared with losses (*b*) and (*c*).

(*b*) *Sensible Heat in the Waste Gases.*—The gases leaving the combustion zone do so at a high temperature, and the descending charge should be caused to take up as much of their heat as possible, because any heat not so taken up is lost to the cupola. To prevent this loss it is necessary to have as many contacts as possible, per unit time, between the hot gases and the charge, for this is the condition under which the gases most readily part with their heat. In a high and narrow cupola the path of the gases is longer and their velocity greater, and for this reason such a form of cupola is preferable; the ratio diameter to height should therefore not fall below a certain minimum. In this connection it should be noted that the employment of the old-fashioned wasteful cupolas of low and wide form was occasioned by the necessity of keeping the charging-door as near the level of the shop as possible. With the development and adoption of lifts there is no longer any reason for continuing this practice. In this connection it is necessary to ensure the avoidance of bad arrangement of the charge or its improper settling in the cupola, both of which allow hot gases to get away without coming properly in contact with the charge, and thus without giving up their heat. This is further mentioned in (*c*).

(*c*) *The Undeveloped Heat due to Unburned Carbonic Oxide.*—There is no need to emphasise the obvious loss of heat when carbonic oxide escapes at the furnace throat. It represents the loss of, roughly, two-thirds the heating value of the carbon consumed in its formation. It is impossible to ensure that no carbonic oxide shall be lost, but any cause tending to increase the amount of the loss should be carefully minimised, or if possible eliminated. Such causes are: (i) lack of adequate blast, (ii) badly arranged charges owing to irregularities in charging, or to projections in the lining upsetting the proper settling of the charge, thus allowing, in greater quantity, air to make its way up one part of the furnace than another, or (iii) improper distribution of the air at the tuyeres with the same result as in (ii), and possibly with the further result that the carbonic oxide is not burned, owing to its being already cooled below the ignition temperature before it receives the air necessary for its further combustion. Dealing with 1 and 2, there are certain points in cupola construction the effect of which has to be considered.

Tuyeres.—Much time and thought have been given to the number, position, and shape of the tuyeres. It is often found that on investigation the results obtained by special shapes, etc., do not justify the hopes of their introducers. The general principle which emerges from the various claims made appears to be only that sufficient area of tuyere must be provided, and that as long as the ratio tuyere-area to cupola-area is kept about a certain figure, the results obtained with one or more rows of tuyeres one above another yield no advantage in the ordinary way, provided at least four to six tuyeres are used. The advantage of more than one row appears to be simply that, in case the capacity of the cupola is increased by reducing the thickness of lining, the necessary increased supply of air can be provided for the heavier output.

Furnace Shape.—The usual shapes are (1) those of equal diameter all the way from base-plate to charging-door, (2) those with smaller diameter from base-plate to a certain distance above the tuyeres. For small cupolas there does not appear to be a great deal to choose between these shapes. In large cupolas, however, the second shape appears to be better for several reasons, viz. :—(1) The coke end is smaller, (2) the blast can get more easily to the centre, (3) the hot gases ascending from the combustion zone are better distributed in the furnace and less likely to make their way up the sides of the charge.

Manipulation.—Charging is done in layers starting from the bed, which must extend 18 in. to 24 in. above the tuyeres; above this in rotation are placed pig, scrap, coke, and limestone. It is necessary to find by experiment the correct weights for the most economical working. As the bed is necessarily about the same weight whatever the length of blow, it follows that it is more economical to run longer blows than shorter ones. The coke charges should be just sufficient to bring the bed to its former level after melting the previous iron charge. Experiments may with advantage be made in reducing the coke charge till the best results are obtained, as an excess of coke not only reduces the economy of the furnace generally, but also the speed and regularity of melting in particular.

Use of Kindling Tuyeres.—In many foundries the practice is to reject the first iron because of its being too cold. This waste may be eliminated by the use of a kindling tuyere placed low down near the sand bottom. This heats up the coke so that the first few cwt. of iron are not chilled. With the cupola of which particulars will be given presently, although very hot iron is required because of the lightness of the castings, no iron has ever to be rejected from this cause. After a bogie or so of iron has been drawn off, the kindling tuyere is shut off and plugged. To put the matter briefly, there are four distinct advantages gained by using such kindling tuyeres, namely :—

(*a*) Hotter iron is obtained at the beginning owing to its having to pass through a deeper bed of glowing

* Paper read before the Iron and Steel Institute.

hot cake. When the kindling tuyere is used properly, all the coke from the bottom up to the melting zone is at white melting heat. The iron on passing through this gathers heat all the way down on its progress to the tapping-hole. On account of the clean condition of the cupola at this stage the iron is probably hotter than any which may be run at any later stage during the day. When the kindling tuyere is not used only the part of the coke bed above the ordinary tuyere is at white heat, and the part of the bed between the tuyere and the bottom is comparatively cold. The iron on its way down through the bed gathers heat until it reaches the tuyere, after which it has to give up heat to the colder part of the coke bed. Under these conditions the first iron melted reaches the bottom almost too cold to run, and certainly too dull for any but heavy castings.

(*b*) The iron being hotter from the first gives cleaner and better tapping-holes and removes the risk of iron solidifying in them. The condition known in the trade as at "iron hole" is much dreaded by the furnaceman. The iron plugs formed in the holes have to be driven out, and in doing this the clay may be cracked and broken, and the holes made too large. When this happens it is difficult, if not impossible, to keep back the slag, and as the slag is usually basic in character it fluxes-out the holes and there is a danger of the whole front being melted-out.

(*c*) Another advantage of using a kindling tuyere is that when the ordinary tuyeres are put to work they start blowing on coke heated to a very high temperature, and are not so likely to blow cold and form the long "spouts" or projections which so often give trouble by preventing the coke from getting near the tuyeres, a condition which invariably results in "bridging" and the production of cold iron.

(*d*) In many cupolas the bottom is so cold and damp that the first iron is chilled and the carbon is arrested in cooling, with the result that the castings have a surface lining of white iron and are quite useless for machining or filing. Such castings might readily destroy or damage expensive tools. When the kindling tuyere is used the bottom and sides of the cupola, as well as the coke bed, are so thoroughly heated that the danger of producing white hard iron is completely removed. A nice grey soft iron, easily filed and machined, can be run at the first as well as at any time of the cast, if this method is applied.

It is a good plan to reduce the blast pressure and the charge of coke near the end of the blow: this saves coke and also the linings, which latter are often badly damaged towards the end of the blow.

The following particulars give the results obtained with a furnace—one of several—the records of which have been drawn upon over a period of fifteen years. In 1901 the average output given was 7.5 tons per hour, with a consumption of 2 cwt. 2 qrs. 6½ lbs. coke per ton. Gradually this was improved until in 1912 the output was 10.8 tons per hour, for a consumption of 1 cwt. 2 qrs. 23 lbs. of coke per ton.

At a later period, to increase this output, the diameter both at the charging-door and at the tuyeres was increased, as was also the tuyere area. The result was an output of 14.3 tons per hour, with a coke consumption of 1 cwt. 3 qrs. 16 lbs. per ton of iron. Subsequently when this rate of output was reduced to 12.8 tons per hour, the coke consupmtion fell to 1 cwt. 3 qrs. 4 lbs. per ton. This appears to show that for every cupola there is a certain output per hour at which maximum economy in coke consumption is attained. It may be stated that while any increase of output beyond this is obtained only with an increase in coke consumption per ton, yet it may pay to "force" the cupola to give such an increased output rather than to build a small cupola as an auxiliary. This is illustrated by reference to the case of a small cupola in which, with an output of 3.12 tons per hour, the coke consumption was as high as 2 tons 0 cwt. 3 qrs. per ton of iron melted.

It must be distinctly understood that the foregoing figures apply exclusively to cupolas engaged on light castings, mainly from 1-8 in. to 5-16 in. thick. Many thousands of these are only of a weight of 2½ lbs. per sq. ft., and the total number of such castings runs into a good seven figures per annum. Further, these cupolas are only run continuously for the afternoon, whereas a whole day's run each time would doubtless reduce somewhat the rate of coke per ton of iron.

Turning to heavy castings, it is much more difficult to get regular figures, because usually foundries engaged on heavy work also make much lighter castings as well, and their records are accordingly difficult to analyse. In general, the consumption of coke per ton of iron melted varies from—for exceptionally heavy work—1 cwt. 2 qrs. to 3 cwt. 3 qrs. where the castings vary considerably in weight.

Generally, it may be safely stated that in large foundries doing mixed work (as most of them have to) the average consumption of coke approximates nearly to 2 cwt. per ton of iron. It is very seldom that such regular working on one particular class of castings is found as that quoted above for those cupolas doing light castings.

The cupolas engaged on light castings and mentioned in the foregoing, show the following ratios:—

Area at tuyeres.			
Area of tuyeres	4.3	5.4	5.8
Height from tuyeres to charging door.			
Diameter at tuyeres	3.8	2.8	5.3
Iron.			
Hours of blast (tons)	10.8	14.3	3.12
	Cwt. qrs. lbs.	Cwt. qrs. lbs.	Cwt. qrs. lbs.
Total coke ..	1 2 23	1 3 16	2 0 3

BASIC REFRACTORIES FOR THE OPEN HEARTH.—The following is a summary of laboratory tests described by Messrs. J. Spotts McDowell and Raymond M. Howe at the end of a Paper on "Basic Refractories for the Open Hearth," recently presented to the American Institute of Mining Engineers:—(1) The magnesite that was lower in lime showed less tendency to slake and higher refractoriness, as well as greater resistance to attack by firebrick and silica brick, and to the action of a corrosive Fe_2P—Fe_2O_3 mixture. (2) The materials highest in impurities and lowest in lime were most resistant to slaking. With one specially prepared dolomite *C* in which the granules had been coated at a high temperature with basic open-hearth slag, the inherent tendency of dolomite to slake had been overcome to a great extent. Another special preparation of similar character *D* (made by mixing together iron oxide and dolomite and calcining at high temperature) showed practically the same degree of slaking as the untreated dolomites. The specially treated dolomite *C* withstood the action of the corrosive mixture only slightly better than the untreated dolomite high in impurities, and much better than a second special preparation *D*. The purest dolomite showed the poorest resistance to corrosion, although this may perhaps be explained by the high ignition loss of the material as received and used. (3) The magnesites were more resistant to slaking than the dolomites or dolomitic preparations and also to the action of the corrosive Fe_2P—Fe_2O_3 mixture and that of fireclay and silica. One of the specially treated dolomites had a slaking tendency so low as to group it with the magnesites as far as this property was concerned. However, in resistance to corrosion it compared more closely with the untreated calcined dolomite high in impurities. Considering these tests only, the value for refractory purposes of the materials studied may be placed in the following order. First, *A*, a magnesite low in lime (3.12 per cent.); second, *B*, a magnesite high in lime (18.94 per cent.); third, *C*, a treated dolomite; fourth, *D*, a calcined dolomite high in impurities; fifth, *E*, a treated dolomite; sixth, *F*, a pure calcined dolomite low in impurities.

Characteristics of Aluminium and its Alloys.

An interesting circular on aluminium and its light alloys has recently been issued by the Bureau of Standards, Washington, from which we give the following abstract:—The metal aluminium constitutes approximately 7 per cent. of the crust of the earth. It exists in clays, in feldspar and other silicates, but for manufacturing purposes only two relatively rare minerals are used, namely, bauxite and cryolite. The former is found at Baux, in France, from which deposit it derives its name, also at Hessen-Nassau, in Germany; in Ireland, and in the State of Arkansas. Cryolite is found at Ivitut, in Greenland. The production of the metal necessitates two operations; one the purification of the ores and the other the electrolysis of the aluminium. The ores contain from 1 to 30 per cent. of iron and silicon, which if not removed would be reduced and enter the aluminium. The metal is produced in carbon-lined pots approximately 3 ft. wide, 3 ft. deep, and 6 ft. long. The carbon lining of the pot forms the cathode, and the electrodes, which are carbon blocks, form the anodes. The temperature of the furnaces ranges from 900 to 1,000 deg. Cent., or 1,652 to 1,832 deg. Fahr. The heating of the pot or furnace is done by the electric current, and approximately 30-kw. hours are required to produce 1 kilogram, or 2.2 lbs., of aluminium.

The process is continuous, and the molten aluminium is tapped every 24 hours into small ladles which are emptied into one large mixing ladle, from which it is cast into ingots. There are two commercial grades of aluminium made in the United States. Grade A contains 99 per cent. or more of aluminium, used for rolling, stamping, and for the production of light alloys. Grade B is also sometimes used for casting purposes, and as a deoxidiser for steel. The impurities in aluminium are principally iron and silicon; sometimes also traces of copper and sodium are found. In Grade A the silicon varies from 0.15 to 0.40 per cent., and the iron from 0.25 to 0.70 per cent.; copper from a trace to 0.05 per cent., and sodium only a trace. Grade B contains more iron and silicon. Aluminium is marketed in the form of "waffle" ingots; a series of squares, 3 × 3 × ¾ in., connected by a thin web, or as notched-bar ingots, about 14 in × 1¼ in. For rolling purposes there are different sizes of ingots as follows:—3½ in × 12 in. × 24 in.; 3 in. × 12 in. × 32 in.; 2 in. × 12 in. × 20 in.; and 1⅝ in. × 12 in. × 18 in.

Aluminium is readily stamped, drawn, and spun. The oxyacetylene or oxygas torch is usually used in welding aluminium, either sheet or cast, and the welds are often so perfect they cannot be detected in the finished article. The process requires experience, and welders familiar with iron and steel generally make failures on trying aluminium. It is sometimes advisable to solder aluminium, in which case the solder is best applied without a flux. The edges of the aluminium must be filed clean, and tinned with the solder, which should be thoroughly rubbed into the surface with a wire brush or with waste. The joint is then readily made in the usual manner between the tinned surfaces, using an iron if necessary. To protect the joint from moisture, which would cause disintegration, it should be coated with a varnish.

Several finishes are given to aluminium. The two most important are the polished and the satin finish. The polished finish is obtained in the usual manner by buffing with rouge, the satin finish is obtained by two methods—by caustic dipping or by scratch brushing. To satin finish by caustic, the metal is first cleaned in benzine, then dipped in boiling concentrated caustic soda; then it is washed and dipped in strong, hot nitric acid, washed in boiling water, and finally dried very quickly. The scratch-brush finish is produced by carefully freeing the metal from grease, then brushing on a wire brush wheel. Pure aluminium is rarely used for castings, because of its softness, high shrinkage, and poor machining qualities. It produces excellent alloys with copper, zinc, magnesium, or combinations of these metals, and when melted with proper care fine castings are obtained.

In general, the casting practice for aluminium alloys follows that for brasses and bronze. The alloys may be melted in graphite crucibles in either oil, gas, coke, or coal-fired furnaces. Electric furnaces of suitable types also may be used. Care is necessary not to overheat the metal, as it then oxidises, absorbs gases, and may at higher temperatures absorb carbon and silicon from the crucible. Good practice favours keeping the temperature of the metal during melting down practically at its melting-point by the continuous addition of solid metal. Pouring should be done at the lowest temperature at which the mould will be completely filled. A temperature of 700 deg. Cent. or below is satisfactory. A low-pouring temperature is especially important for aluminium alloys because of their high specific heat. If poured at a high temperature, the metal in cooling so heats the mould that the rate at which the casting cools is very slow, and a coarse grain and weak metal result. No flux should be used in melting down, and the surface should not be covered with carbon, as this may be included in the casting. Just before pouring, however, a small amount of zinc chloride may be added with advantage. This thoroughly cleans the surface and prevents dross from entering the casting.

Two characteristics of the metal influence the production of good castings. First, the metal or its alloys are quite brittle or hot short at temperatures just below the melting-point, and, secondly, they are light, or of low specific gravity. The first characteristic makes it necessary to have soft and yielding cores and moulds, which means that green sand should be used whenever possible and hard ramming avoided. The mould should be poured carefully and not too rapidly, as the metal may otherwise fail to fill it completely. The casting should be stripped as soon as set to prevent its cracking. For ordinary brass-foundry alloys, the patternmaker's allowance for shrinkage is 0.156 in. per foot; for aluminium the shrinkage allowance is 0.203 in. per foot. Probably 95 per cent. of the aluminium castings made in America are from the No. 12 alloy, consisting of aluminium 92 per cent. and copper 8 per cent. This alloy has a melting range of 637 to 540 deg. Cent., a shrinkage of 0.156 in. per foot; a tensile strength, when properly melted, of 18,000 lbs. per sq. in.; an elongation of 1.5 per cent., and specific gravity 2.89.

Aluminium alloys are also used containing from 8.5 to 14 per cent. copper. These alloys are used for castings which are to be subjected to high

temperatures, such as manifolds, pistons, and also for castings to withstand pressure, such as pumps. The 8.5 to 11 per cent. copper alloy is generally used for pistons, and the 11 to 14 per cent. copper alloy is used for pressure castings. Of the copper-zinc-aluminium alloys, No. 31, consisting of aluminium 82 per cent., copper 3 per cent., and zinc 15 per cent., is extensively used abroad. The alloy has more tensile strength than No. 12; usually from 22,000 to 25,000 lbs. per sq. in. One of the earliest commercial aluminium alloys is magnalium, which originally contained from 5 to 30 per cent. magnesium and also small quantities of copper and nickel. This alloy can be depended upon to have around 20,000 lbs. per sq. in. tensile strength, with from 0.5 to 0.2 per cent. elongation. With care a tensile of 25,000 lbs. per sq. in. may be obtained with 5 per cent. elongation.

Another aluminium-zinc alloy used for general castings contains 35 per cent. of zinc, the remainder being aluminium. This alloy has a melting range from 585 to 440 deg. Cent., a shrinkage of 0.156 in. per ft., a specific gravity of 3.32, and a tensile strength of 35,000 lbs. per sq. in., but it has little or no ductility. Alloys of aluminium, manganese, and copper also find some application. These may contain from 1 to 2 per cent. copper, 1 per cent. manganese, and the balance aluminium.

Correspondence.

To the Editor of the FOUNDRY TRADES JOURNAL.

SIR,—During the last three years, inspired by the efforts of far-seeing firms, the Welfare Movement has made very rapid strides in this country, and the wide recognition now being given to it by employers, workers, and public men leaves little doubt but that within a few years it will occupy a very prominent position in the industrial world. So far, no real attempt has been made either by State or voluntary agencies, to collate information regarding various phases of the work; in fact, the names of firms interested in the movement are not even recorded in any place. The Industrial Welfare Society is anxious, for the benefit of industry generally, to collect from the pioneers of this movement, information regarding their doings in connection with Welfare Work. I shall therefore be grateful if those firms who are willing to assist in this way will apply for particulars of the information desired, to the Industrial Welfare Society, 33, Tothill Street, Westminster, S.W.1.

ROBERT R. HYDE.

September 9, 1919.

With reference to the magnetic sclerometer described in another part of this issue we have received the following communication :—

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—The new magnetic sclerometer has aroused great interest among the Universities and Technical Schools, and we have received many applications for the loan of an instrument.

Wishing to lend every possible assistance to laboratory research and demonstration, we have decided to lend an apparatus, complete with samples of different steels having varying heat treatments. This apparatus will be on loan, for short periods, for purposes of demonstration, and will be supplied to recognised educational authorities upon receipt of an application from principals or senior demonstrators.

Yours faithfully,

AUTOMATIC AND ELECTRIC FURNACES, LIMITED.

September 11, 1919.

Use of Manganese in Cupola or Ladle.

The value of manganese in many castings is unquestioned. It makes a closer grain, and prevents the cutting action of many corrosive substances. Few of the ordinary pig-irons go above one-half of 1 per cent. in manganese, and to get a large percentage in the casting it is necessary to add a high manganese pig or spiegel to the cupola charge or else add ferro-manganese in small lumps to the metal as it runs into the ladle. With hot metal several hundred pounds may be added in this way. When ferro-manganese was used in large quantities, 200 to 300 pounds to the ladleful, it was noticed that the manganese would combine with the sulphur present and carry a large amount of it to the top of the ladle. It would be possible to skim the ladle and thus reduce the sulphur considerably. The same thing is true in casting; the melted manganese seizes the sulphur and floats it to the very top of the casting.

This was proved in many instances; the most remarkable one was the difference between the bottom and top of a 2,000-pound roll. The surface of this roll was difficult to machine, and drillings made from the top of the roll showed 1.07 per cent. in sulphur and 1.02 per cent. in manganese. In pouring heavy cylinders the same thing was noticed. On one or two occasions it was observed that these risers would show white iron in the centre with a well defined grey iron toward the surface. As this was a curious exception to the general rule, portions of each iron were tested for sulphur and manganese. The white interior showed 0.70 per cent. sulphur with 1.80 per cent. manganese. The grey exterior showed 2.66 sulphur with 2.10 per cent. manganese. When it was noted that this metal, normally, would not run over 0.06 in sulphur, this separation of the metalloid in the riser is remarkable.

These instances might be multiplied, but they suffice to prove that ferro-manganese added in the ladle will float the sulphur to the top of the casting. On the other hand, when castings are made by adding high-manganese pig to the cupola charges, no such action of the manganese is observed and there is no difference between the bottom and the top of the casting in sulphur percentage.

MALLEABLE CAST-IRON.—We have recently received an interesting booklet, prepared by the American Castings Associations, dealing with the scientific production of malleable cast-iron. In a foreword they remark that the first malleable cast-iron, of which we have record was made by Réaumur, about the year 1720. We also know that Lucas, in 1804, and in later years, Lenox and Boyden, worked with this metal. However, it is only within the last few years that research and an exchange of information have made possible the rather remarkable advance and improvement enjoyed by the industry, and have placed its plant operation on a really scientific basis. The booklet is divided into three parts. Part I. gives an elementary explanation of the physical character of malleable cast-iron. Part II. deals with experimental work carried out by the American Castings Association, while Part III. treats of the applications of malleable-iron castings. Under the heading of "Research Work on Malleable Cast-Iron," an interesting article appears in another part of this issue, describing the work carried out by the Association.

Macrography of Steel.

In a recent issue of the "Revue de Métallurgie" MM. H. Le Chatelier and B. Bogitch describe in detail the theory of macrography, from which we give the following extract:—If a polished steel surface is treated with suitable reagents certain patterns are produced, proving that the composition of the steel under test is not homogeneous. Thus, if sulphuric acid is used for etching, furrows appear which indicate the trend of the fibres produced by rolling. Similarly, tincture of iodine, after a few seconds, will reveal all the impurities in the metal, especially those within the zone of segregation. Finally, Dr. Stead's cupreous reagent produces patterns of corrosion more distinct than those due to the other two etching media.

The branch of science dealing with these tests, which produce results visible to the naked eye, is called "macrography" to distinguish it from "micrography," which investigates the microtexture of the material.

The method of disclosing an unevenness in the microtexture of metal was discovered by Sorby and more fully studied by Osmond. The heterogeneity is due to an uneven distribution of carbon, the cells being of the size of a hundredth part of a millimetre. The form of pattern in which they are grouped is highly unstable; it changes with every heating and disappears entirely after quenching. The cause of the heterogeneity is not known exactly but generally it is ascribed to the impurities in the steel.

The macrographic structure is produced by the grouping of compartments or cells which are on an average one hundred times the size of the micrographic cells. The pattern itself, in this case, is indelible. It does not vary in the same sample whatever kind of heat-treatment the metal may undergo.

There is no correlation whatever between these two kinds of structure. The surface of the steel specimen may be compared to a sheet of paper upon which two independent series of characters have been printed, one series consisting of large characters impressed in indelible carbon black ink; the other composed of smaller characters ranged in some other way and printed in aniline dye, which can easily be obliterated and will allow of the design or pattern being altered over and over again. The quality of steel is in close relationship with the hetereogeneity disclosed by the two methods of investigation.

Dr. Stead considered that the macrostructure, as revealed by his reagent, was due to the presence of phosphorus. As a result of their investigations, described in full in their memoir, the authors consider that they are able to prove that the macrographic structure is due to the oxygen that has remained in solution in the solid metal.

From a general survey of the facts observed the authors draw the following conclusions:—

(1) The only element which will produce the chemical heterogeneity in steels that have been annealed or slowly cooled down from their melting temperature is oxygen and no other element will, in the absence of oxygen, produce the same effect.

It has been known for a long time that oxygen exists in solution in the molten metal, as the oxide

Fig. 1.—Electrolytic Iron Cast in an Atmosphere of Hydrogen.—Etched with Cupric Reagent.

Fig. 2.—Electrolytic Iron Oxidised by the Gases during Melting.—Etched with Cupric Reagent.

FeO, and it was admitted that at the moment of solidification this oxygen separated from the metal, partly as oxide of carbon, which produced blowholes, or piping. In reality a portion remains in the solid solution, but its distribution is not uniform; the parts of the steel which are the last to solidify being the richer in oxygen. Like all similar solutions, the composition varies from point to point, so that the boundary lines between the oxidised and the purest portions crystallised at the beginning of solidification, are not well defined, but present the so-called "cored" structure.

It is, however, not impossible that some of the oxygen is present in the steel as an oxide in conjunction with some other element than iron; principally in the form of a phosphate of iron or an oxy-phosphide of iron.

(2) When the oxide-of-iron content of the metal is under 0.01 per cent., Stead's cupreous reagent does not disclose its presence. When the percentage is higher than 0.01 the action of the reagent is the more effective, but only up to 0.1. When the

percentage of oxide-of-iron content exceeds 0.1 to 0.2, the effect of the reagent becomes gradually more feeble with the increase in the percentage of the oxygen content. Thus, highly oxidised steels, made in the open-hearth or in a converter, which have not received their final dose of silicon and manganese, are hardly attacked by the cupreous reagent.

(3) Stead's cupreous reagent preferentially attacks the purest portions of the metal, that is those least oxidised; with all other reagents in macrography the effect is the reverse. The presence of oxygen in the steel enhances the effect of the latter class of reagents on the metal, without, however, the oxide of iron itself being appreciably dissolved. The result is a greater contrast between the portions of metal not equally affected; those most affected becoming dark owing to the formation of a black deposit of oxide of iron.

(4) The test with gelatino-bromide paper only discloses the presence of sulphur in the metal.

Figs. 1 and 2, taken from the authors' memoir, illustrate respectively pure electrolytic iron, cast in an atmosphere of hydrogen and free from oxide and the same sample of iron oxidised by the gases during melting.

In brief, oxygen plays the same part with reference to the macrostructure of steels as does carbon in reference to their microstructure. In the same way as there are reagents which attack in preference the pearlite, or the cementite, the cupreous reagent attacks in preference the portions of the metal which contain less oxygen; while other reagents (double chloride of copper and ammonia, iodine, hydrochloric acid, etc.) act in the opposite way. In the absence of oxygen all the reagents investigated only disclose differences in the crystalline structures.

Preventing Accidents with Ladles and Crucibles.

Under this title a useful article appears in a recent issue of "The Foundry," by M. H. Potter, who, while admitting that in almost all casting plants the general hazards of foundry operations are carefully guarded against, considers the unusual hazards are liable to escape notice, and it is for the purpose of preventing accidents from such hazards that the following suggestions are made.

Bull or double-handled ladle bowls should be so balanced on their trunnions that they will remain erect regardless of the amount of metal which they contain. A top-heavy ladle is a menace, while a ladle provided with an excessively heavy bottom strains the operating mechanism unnecessarily and makes smooth pouring difficult. Ladle shanks should be of sufficient strength for the purpose for which they are intended, and since the strain usually is greatest at the joint, these should be securely welded. The shanks should be inspected periodically for flaws which may develop in the welds, or for other weaknesses caused by erosion of molten metal or by wear. Discarded ladle shanks should be scrapped immediately and defective shanks should be promptly removed and repaired. Also, ladle shanks should be protected from rust in storing. The shanks should be securely attached to the bowls of single-handed ladles when practicable. Ladles with detachable bowls that are liable to slip out of their shanks when upturned, although requiring less storage space, are not safe for handling metal. Whenever detachable bowls are used, they should be made a wedging fit into the shank rings and they should be balanced to prevent the tendency of the bowl to fall out when tilted. Care should be exercised in fitting the bowl in the shank rim to prevent cracking the lining. A rigid fork at the opposite end of the bull ladle-shank will enable moulders to carry and empty the bowl more evenly than when both ends of the shank are rigid. The man pouring at the swivel end does not interfere with the control of the ladle by the man at the rigid end of the shank. Iron straps should be employed to hold the bowls securely in their shanks. Ladles equipped with operating mechanisms should be so constructed that they cannot be turned over accidentally. None of the strain of controlling the metal flow should be borne by the operator. Due to the rapid wear of gears and pinions, they should be inspected at regular intervals. To avoid confusion, all mechanically-operated ladles in the shop should turn in the same direction when pouring. Gears, pinions, hand wheels and trunnions which are liable to work loose, should be held securely by tapered pins, lock washers, double nuts or set screws. Gear covers, readily detachable for inspection purposes, should be provided. Means for fixing the ladle in an upright position while it is being conveyed to the pouring floor or at rest, also should form a part of this equipment. A device of this kind will prevent rocking or upsetting the ladle.

The work of lining ladles should be entrusted to one capable man. It is neither desirable nor safe to permit each moulder to line the ladle bowls which he uses since, as a rule, he prefers a light ladle to a safe one. Furthermore, if this work is delegated to one man, he soon becomes expert in the task. The drying of ladles always is an important safety factor, since the contact of molten metal with a moist lining may result in an explosion. Special ladle heaters are desirable for this work and are used by many foundries. However, large core ovens or crucible furnaces also may be employed. Ladles should be supported above the ground a sufficient height to provide ample air space between the bowl and the ground to prevent the absorption of moisture. Not only should they be inspected regularly when not in use, but a watchful eye should be kept on the linings while in the service to detect thin spots or breaks. Dangerous spattering of metal will be avoided when filling hand ladles from a continuous stream, by cutting into the stream from the front instead of the back. A novice should never be entrusted with the pouring of metal from crane ladles, nor should a recently employed moulder be permitted to carry ladles of molten metal until he has been around the shop several weeks and has familiarised himself with existing conditions. When carrying a hand ladle the workman should keep the bowl behind him. The inspection of crucibles should be critical and should begin when they are received. All crucibles should be dried out before they are charged. The top of a continuously-operated core oven is an ideal place for storing them. Also, waste gases from furnaces or ovens may be employed advantageously for this purpose. Such gases, however, should not come into direct contact with the crucibles to deteriorate them.

When annealing crucibles, they should be heated slowly and uniformly to dull redness and they should be prepared for annealing by heating them to a temperature of about 220 deg. Fahr. To prevent the absorption of moisture by crucibles after annealing, they should not be allowed to cool before charging.

When subjected to melting temperatures, crucibles become soft and pliable and are easily deformed by concentrated pressure. The slightest deformation of a crucible is liable to develop cracks when it cools. Therefore, crucible bottoms should be kept free of clinkers and they should be set on well-prepared fuel beds. A firebrick bed is recommended for this purpose. The metal should be charged loosely to prevent wedging, or otherwise the expansion of the metal will strain the crucible walls.

Cast-Iron Scrap.

We give below an extract from the Report of a Committee appointed by the American Foundrymen's Association to draw up foundry-scrap specifications.

From the Report, which covers a large variety of scrap, we select that dealing with cast iron :—

No. 1 *Machinery Scrap.*—This material shall consist of cast-iron scrap of first quality which possesses evidence of having been machined, such as planed or turned surfaces, bored or drilled holes, etc. It must be cupola size, no piece to weigh more than 100 lbs., and must not exceed 24 in. in length or width. It shall be classified as follows :—

Heavy, pieces greater than 1 in. in section.

Medium, pieces ½ in. and not to exceed 1 in. in section.

Light, pieces not to exceed ½ in. in section.

Scrap classified as railroad cast scrap or under any other classification of these specifications, and burnt iron of every description will not be accepted under the foregoing classifications.

No. 2 *Machinery Scrap.*—This shall consist of cast-iron scrap of first quality which possesses evidences of having been machined, such as planed or turned surfaces, bored or drilled holes, etc. It shall be in the unbroken state. It shall be classified as follows :—

Heavy, pieces greater than 1 in. in section.

Medium, pieces over ½ in. in section and not to exceed 1 in.

Light, pieces not to exceed ½ in. in section.

Scrap classified as railroad cast scrap or under any other classification of these specifications, and burnt iron of every description will not be accepted under the foregoing classifications.

No. 3 *Rough Scrap.*—This shall consist of cast scrap, such as columns, pipes, plates and rough castings of a miscellaneous nature broken to cupola size, pieces not to exceed 100 lb. in weight and must not exceed 24 in. in length or width. It shall be classed as follows :—

Heavy, pieces greater than 1 in. in section.

Medium, pieces over ½ in., and not to exceed 1 in. in section.

Light, pieces not to exceed ½ in. section.

Scrap classified as railroad cast scrap or under any other classification of these specifications, and burnt iron of every description will not be accepted under the foregoing classifications.

No. 4 *Rough Scrap.*—This shall consist of cast scrap, such as columns, pipes, plates and rough castings of a miscellaneous nature in the unbroken state. It shall be classified as follows :—

Heavy, pieces greater than 1 in. in section.

Medium, pieces over ½ in. and not to exceed 1 in. in section.

Light, pieces not to exceed ½ in. in section.

Scrap classified as railroad scrap or under any other classification of these specifications, and burnt iron of every description will not be accepted under the foregoing classifications.

No. 5 *Machinery Scrap.*—This shall consist of burnt machinery scrap of miscellaneous character, but must not include any burnt material included in any other classification of these specifications.

Stove-Plate Scrap. — This shall consist of the best class of clean stove plate. It must be free from malleable-iron and steel parts, grates, burnt iron and other miscellaneous scrap usually collected with this material.

Scrap classified as railroad scrap or under any other classification of these specifications, and burnt iron of every description will not be accepted under this classification.

No. 2 *Stove-Plate Scrap.*—This classification includes all unburnt cast-iron stove parts not included in the No. 1 stove-plate classification.

Scrap classified as railroad scrap or under any other classification of these specifications, and burnt iron of every description will not be accepted under this classification.

No. 3 *Stove-Plate Scrap.*—This shall consist of burnt stove parts of every description, but must not include any burnt material included in any other classification of these specifications

No. 1 *Agricultural Scrap.*—This shall consist of cast-iron parts of agricultural machinery and shall be free from steel, malleable, chilled iron, such as plough points, etc., and burnt iron of every description.

No. 2 *Agricultural Scrap.*—This shall consist of chilled iron parts of agricultural machinery and must be free from steel, malleable and burnt iron of every description

No. 1 *Railroad Scrap.*—This shall consist only of chilled cast-iron car-wheels conforming to the Master Car Builders' Association standards.

No. 2 *Railroad Scrap.*—This shall consist of miscellaneous cast-iron car-wheels not included in the No. 1 classification.

No. 3 *Railroad Scrap.*—This shall include only plain grey-iron brake shoes, which must be free from steel backs and inserts.

No. 4 *Railroad Scrap.*—This shall include steel back and insert brake shoes of both driver and car types. It shall not include brake shoes of the No. 3 classification.

No. 5 *Railroad Scrap.*—This shall consist of railroad burnt iron of every description.

No. 6 *Railroad Scrap.*—This includes unburnt railroad grate bars and grate-bar rests, and journal boxes with steel parts removed.

No. 1 *Radiator Scrap.*—This shall consist of radiator castings, broken, with all steel, malleable and other parts removed. It must be free from scale and excessive rust or corrosion.

No. 2 *Radiator Scrap.*—This shall consist of radiator castings, not broken, with all steel, malleable and other parts removed. It must be free from scale and excessive rust or corrosion.

NEW MOULDING MATERIAL. — A writer in a recent issue of the "Canadian Foundryman" says that our modern methods of moulding are to all practical purposes the same as those which were practised by the Egyptians 4,000 to 5,000 years ago. From this he proceeds to a brief description of a discovery by William M. Hoffman, of Buffalo. N.Y., who claims that he has found a new moulding material. While exploring corundum veins in the Blue Ridge Mountains of North Carolina, he came upon a surface of combination amphibole and actinolite. These minerals belong to the same class as asbestos, with the addition of magnesia and other minerals of a refractory nature. It is claimed that with a proper binder, which is said to have been perfected, it is possible to use these materials for permanent moulds. No data as to the method of using such moulds, their life, and way of restoring the mould face are given in the original article.

PROTECTING MOLTEN ALLOYS FROM OXIDATION.—A difficulty in melting alloys, and some metals, is the oxidation of the metal, whereby serious loss of material occurs. To meet this difficulty, it is a common practice to fill the container with a neutral gas so as to effect the fusion in a neutral atmosphere. But the usual arrangements allow the neutral gas to escape, its place being taken by air from the surrounding atmosphere. As a consequence, some oxidation still occurs. An invention, patented in Germany, remedies this effect. The container in which the metal is melted is constructed to be closed air-tight, and put in communication with a compressed air-cylinder filled with nitrogen. The gas, under a pressure of 60 to 70 atmospheres, may be led into the container through a reducing valve.

Foundry Comparisons.*

By H. G. Barrett.

There is no "cut and dried" road to success in the foundry, and efficiency is only arrived at by a steady survey and continual super-vigilance. Foundrymen are few and far between who do not preserve a mental record of the difference between one piece of work and another passing through their hands from time to time; and although the same general order of practice follows, no definite rule can be rigidly adhered to by which the foundry worker can govern every succeeding job. Foundry work becomes more varied and complicated by modern demands and the growing knowledge of many possibilities now being discovered in connection with the foundry industry.

Foundry work requires something more than mechanical ability. The moulder, to be successful, must understand the underlying principles involved in the work. Deductions must be made before he can proceed, and even then, in some cases, efforts are wasted sometimes between the first sand on the pattern and the last cramp on the box. During the last few years the foundry has taken a place in the front rank of essential industries, and its capabilities are being taxed more than ever by the fresh demands now being made upon it. Taking the foundry of fifty years ago and the foundry of to-day, although the principles are the same, they are scarcely comparable.

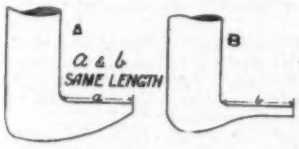

Fig. 1.

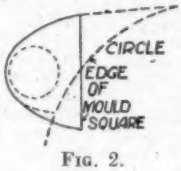

Fig. 2.

Fig. 3.

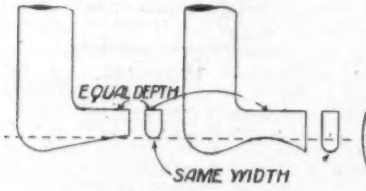

Fig. 4

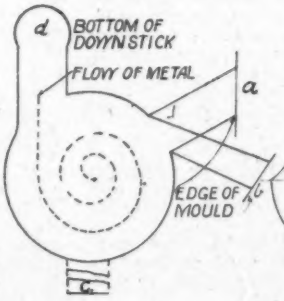

Fig. 5.

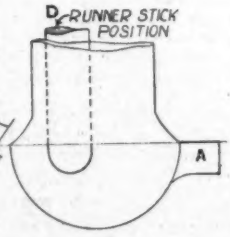

Fig. 6.

Runners.

To make a comparison of the vast number of runners now in use would need an exhaustive survey, but runners conform to one principle, i.e., that of affording a space through which molten metal can enter the mould. If that were the sole function of runners, it would be well for the moulder, who always tries to imagine the place for the runner stick is in the corner of the moulding box. Waste castings can often be traced to thoughtless running. Fig. 1 (A and B) illustrates the difference between two simple runners that can be used for a casting of a plate type. The runner *a*, Fig. 1, is often used by thoughtless moulders, with the result that the metal is forced into the mould in an upward direction, striking with some amount of force against the top part or falling in a curve on to the bottom. In each case the removal of a small particle of sand is enough to start a scab on the casting. If the plate is of fairly large dimensions, and the metal is being directed to one spot in this way, failure must result. The example *b* is a more efficient runner for a plate, as the metal can enter the mould in a direct line with the space to be filled. Fig. 2 illustrates the fact that when a plate is thin provision should be made, if possible, to give width to the runner at the edge of the mould, which should at least be equal in area to the down-stick; this allows the metal to freely flow into the mould, whilst a small inlet creates a certain resistance. The broken lines show how the runner can be extended to suit a circular plate and assist by the direction of the flow of the metal to get a sharp edge to the casting.

Fig. 3 illustrates a type of runner where the inlets to the mould can equal the area of the down-stick. If the casting is very thin and several sprays have to be cut another down-stick can be added to get the required volume of metal to enter the mould for rapid filling. The increase in the number of sprays helps to give equal pressure over the whole surface of the mould without the force being directed to one point. The part ex-

* Paper read before the London Branch of the Institute of British Foundrymen.

tending beyond the inlets serve the purpose of trapping some of the dirt which is pushed forward by the first flow of the metal.

Fig. 4 illustrates a type of runner made by some moulders, but which proves a source of trouble, owing to the metal being forced into the mould under pressure, the small part of the runner being directly at the edge of the mould, where a resistance takes place owing to the amount of pressure directed towards it from a larger channel. A runner of the same type, but preferable to Fig. 4, is shown in Fig. 5. It will be noticed that midway between the down stick and the mould surface the runner has a smaller area than at the entrance to the mould. A runner of this type does not prevent the whole of the force, but it does assist in preventing the metal cutting into the surface of the sand. This is a good type of runner to use if it is not convenient to run at the bottom; especially in the case of deep brackets or ribs, when the runner is cut deep at the part entering the mould, the metal will pass and fall to the bottom without being forced at the entrance to the mould.

The use of sullage or dirt runners is neglected

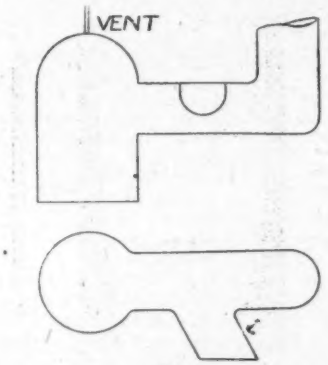

FIG. 7.

in many foundries, on account of the amount of time taken up by cutting runners of the sullage type. After an initial outlay runners of this description will not take any more time to make than runners of the ordinary kind. Once a pattern is made, cast-iron ones do not take up much time to produce. The principle of this runner (seen in Fig. 6) is not thoroughly understood by every moulder, although when once explained it can be appreciated more by the efficiency of its application. This type of runner is sometimes inefficient, owing to the inlet from the down stick to the sullage base not being at the required angle with the inlet to the mould. The broken line *c* indicates where it would be almost useless to place the inlet from the sullage base to the mould. The two being in almost a direct line allows the first rush of the metal to pass into the mould some of the dirt this kind of runner should prevent from entering. This can be prevented if the angle of the runners is as shown at *a* and *b*. When the metal enters the base it is set spinning, and any impurities are carried towards the centre and forced up the opening or riser above the base. The opening should be large enough to allow the metal to pass up with the least possible resistance. A common error is made in not having this part of the runner large enough to allow the metal to rise without some amount of force. If there is not room on the top of the box to allow of a large stick being passed through, a small stick can be used and the opening tapered at the bottom after lifting the top part. Another type of this runner can be made by taking a piece out of the joint with a tube before the pattern is drawn out of the sand, as in Fig. 7. Opposite the hole made by the tube a hollow should be formed, and a vent-wire run through the top part to allow the metal to pass up into the hollow without any air resistance. A channel is cut from the down-stick to the part taken out by the tube. This channel should be deeper than the inlet from it to the mould. The inlet to the mould should be at an angle, as in Fig. 7. This allows any dirt to pass by with the first flow of the metal, and be carried into the part taken out by the tube, allowing the clean metal which follows to enter the mould.

Fig. 8 is a type of runner that can be used to advantage on many non-ferrous moulds where it is convenient to run the mould from the top, especially if "feeding" is required. A large stick is rammed up on the pattern in the usual way.

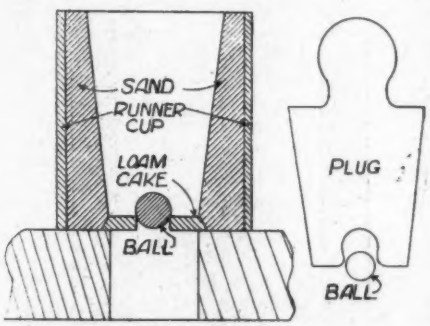

FIG. 8.

(The stick should be one that would be used for the riser.) The hole is then covered by a loam cake, the hole in the loam cake being large enough for the runner. The edge of the hole through the loam cake is rubbed down by a metal ball the same diameter as the runner plug. The ball is placed over the hole on the loam cake and a taper plug having a hollow under the centre of the bottom to pass over the ball on the runner is stood upon the loam cake. The runner is then rammed up in the usual way and the runner stick withdrawn, any dirt in the runner being blown out (the ball being metal will not shift during this operation), which insures a clean runner. The runner is plugged in the ordinary way when about to cast. When the mould and runner have been filled with metal, a hook can be inserted down the runner and the loam cake lifted out, this allows the full dimension of the riser for feeding.

When a number of castings are to be made there will be a considerable saving in metal from runners if this plan can be adopted. When the heads are broken off non-ferrous metal runners and risers, water should be poured upon them to assist in freezing the fracture as soon as possible. The outer surface of metal in the runners and risers freezes rapidly, causing a chill surface, which is a

trap for, or resistance against, any part of the alloy being forced out into the sand during the period of contraction. When the heads are broken off, the centre which is at the highest temperature, is exposed, and in some cases part of the alloy is above its melting point, and is expelled by contraction. When once a channel is formed it can in some instances, if the runner and down-stick are fairly large, be traced into the casting. This would be detrimental in a casting to stand internal pressure.

A similar effect takes place sometimes if gases are absorbed in the metal during melting, especially if the metal is allowed to soak or melt very slowly. The exit of the gases into the runner or riser forms a line of porosity as the metal reaches a plastic state, and results in leaky places.

The writer was recently connected with a foundry where considerable time was given to the question of runners. Almost the whole of the work done by machine moulding had runners made for the job, which were attached to the patterns for storage after use. The saving of wasters from indifferent running can be appreciated, after having seen the result of such a system.

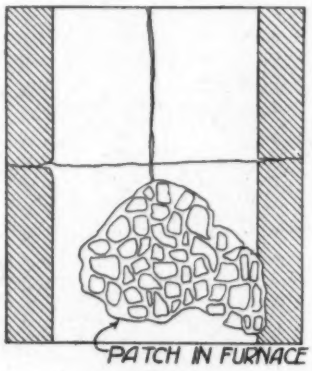

FIG. 9A.

A great amount of metal can be saved if the question of runners be kept in mind. Large quantities of iron are wasted in some shops by runners being heavier or larger than they need be; if there is a large number of castings of the same size and weight, a pound or so saved from each runner means a large amount of metal saved in the end.

Waste.

The rubbish heaps in some foundries contain an amount of waste which, with a little care, could be used in reducing the "consumables" and assist in cheapening the cost of production. The foundry labourer in many instances is the greatest offender in this respect; while some moulders seem quite unconscious of the amount of waste they create. In the same way one moulder will work methodically and neatly, while another will cause the ground allocated to him to appear more or less in a state of confusion. Much has been said about throwing old crucibles away. The following is a good way to use old crucibles in a non-ferrous furnace:—When the walls of a furnace begin to burn away and require patching, broken crucibles can be ground up with the gannister and the mixture made less plastic than it is usually worked; the furnace should then be patched in the usual way, and as soon as this is done broken pieces of crucible should be dipped in thick clay-wash and forced into the patches as close together as possible (Fig. 9A). The pieces should be forced in with a wood or hide mallet, so as not to fracture them to the extent that would occur if a hammer were used for the purpose.

When the preheater is fitted to a non-ferrous furnace, the diameter of the orifice is governed by the size of the crucible the furnace has been designed to carry. As the gases rush through the preheater, they tear away the edges of the bricks, and cavities appear, continual patching being required to preserve them. Fig. 9B illustrates a simple method of overcoming the difficulty. When the bottom of a crucible has given out and the walls are intact, cut the bottom away with a half-round file, or some instrument with a sharp edge; cut enough of the crucible to leave the wall the same depth as the preheater. Give the preheater a coat of very thin gannister, and coat the outside of the crucible wall with a thick clay-wash. Then force the broken crucible down into the preheater to get a good joint between the bricks and the crucible.

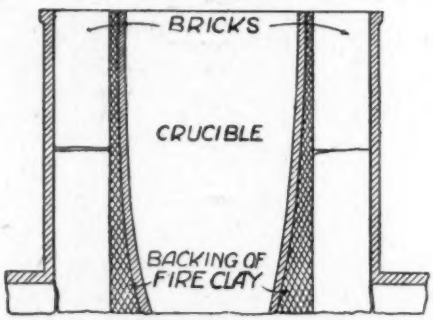

FIG. 9B.

Some of the gannister will squeeze out at the top and bottom, and can be wiped round with a brush and water to form a good joint.

A forced-draft, coke-fired furnace, designed for a 200-lb. crucible, from the time of new bricks being put in and patching in the ordinary way was re-bricked after 280 meltings of gun-metal and brass. After re-bricking and patching in the way described 340 meltings were obtained, including two meltings of iron. Old fire-bricks, broken crucibles and gannister ground up together in loam will make an excellent patching material.

It is common practice in many foundries now to use wax vents for cores that present some difficulty to vent and where the use of wax-venting proves a safe and quick means of overcoming the difficulty. In some core rooms the wax vent lays about on the bench, with the result that it gets damaged, and useless lengths are cut off and thrown away. This waste can be prevented if a board is made as shown in Fig. 10. This will quickly pay for the expenditure.

Wax vents are supplied in rolls, with a space in the centre large enough to pass a piece of wood through of ¼ in. diameter. The board may be marked out as shown, the lines and numbers being inch divisions put in with white paint on a black

ground. The brackets at the top of the board are placed in position, far enough apart to allow the roll of wax vent to pass between, supported by the roller resting in the brackets as shown. When a piece of wax vent is wanted, it can be pulled down to the required length and cut off; a knife or pair of scissors should be suspended by a cord at each end for the purpose. A small box should be attached to the board, to receive any short ends which are left over at the finish of the roll.

The Brass Foundry.

Many moulders outside the brass foundry imagine the work of the brass moulder to be somewhat of a simple nature compared with other branches of the founding industry. It is only after actual experience in non-ferrous work that they arrive at the opposite conclusion. There are many defects in non-ferrous work directly due to the mould. Bronze, gun-metal and brass castings scab very easily in green-sand moulds, in many cases as the result of the sand being too wet. Sometimes when a mould is rammed hard enough to resist the penetration of parts of an alloy, the venting is insufficient to allow the gases to pass through the tightly rammed sand. Some scabs can be traced to the positon of rammers and to the metal entering the mould being deposited in patches on the surface, where it becomes chilled and adheres to the surface of the mould; the metal following, sweeps the chilled portion away with the surface of the mould attached to it, leaving the surface of the mould recently covered by the chilled portion disturbed, with the result that porosity occurs or a dirty casting is produced.

The ramming of a mould in a brass foundry needs more attention than some moulders care to give it; but when one considers the range of temperature and specific gravity between a high-class phosphor-bronze and an aluminium alloy, the question of ramming needs some consideration. If a mould for gun-metal, bronze or brass is rammed soft, the result will be a casting with an irregular surface, and consequently a large amount of loss by grinding or turning. This also occurs in some instances where the work is "bedded-in," or weak box parts are used and secured tight at the lugs to prevent the top part lifting with the pressure. When the pressure comes against the top part it bows, which results in the casting being slightly domed at the top towards the centre.

Hot metal poured into the mould sometimes causes irregularity of the surface, which is credited to the moulder. In some foundries the temperature for pouring the metal into the mould is not considered as it should be.

Difficulties are sometimes overcome by large risers. The chief essential is to give the casting as large a riser as is possible, to govern the area of liquidity, when the last place to freeze will be directly below the riser, and the cavity, if there is any, will be in the riser and not in the casting. There is trouble in cutting off large risers, but not so much trouble as there would be to remelt and mould another casting.

The mechanical efficiency of non-ferrous alloys depends upon the arrangement or distribution of the constituents, just as much as it does upon the quality or quantity used; and opinions differ as to the correct method of obtaining perfect homogeneity in the casting. Trouble is often caused in foundries when the metal is allowed to "soak" in the furnace after it is in a molten condition, with the temperature sufficiently high for pouring. Loss of metal occurs in this way, and although the amount in each case may be small, if totalled results in a great loss. The mould should be ready for the metal before the metal is ready for the mould. It does not indicate good practice to have fumes rushing from the surface.

Many foundrymen are indifferent about stirring metal; it should not be stirred vigorously, as that exposes more of the metal to the atmosphere than is necessary. When vigorous stirring takes place the oxide is taken down into the metal where it is trapped or held suspended in some instances, especially in a light alloy or any metal where the oxides are of nearly the same specific gravity as the metal.

Malleable-Iron Work.

In the malleable cast-iron foundry are discovered many difficulties which are not met with in grey-

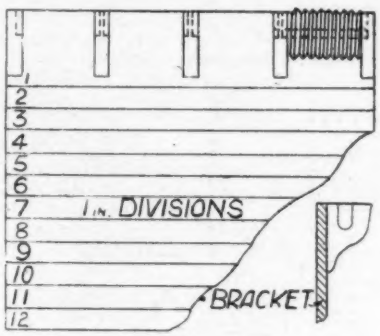

FIG. 10.

iron work. When the metal is in a liquid state there is a very rapid lowering of the temperature, and the excessive contraction often calls for a large amount of ingenuity on the part of the moulder to produce a sound casting that would be a simple job in grey-iron. Grey-iron castings, when taken from the mould, in almost every instance, pass directly to the trimmer and delivery. With a malleable-iron casting much has to be done first. Many of the failures in the malleable foundry are directly due to indifferent designs, produced by people who do not know the difficulties of malleable production. In one case it may necessitate a large number of risers, which means waste of metal. In another, chills may be needed to prevent faulty castings.

Facing sand should not contain the amount of coal dust that would be necessary for grey-iron. The metal being poured into the mould at a high temperature would cause the coal dust to run before it and produce dirty castings. Or small pits would appear on the surface, owing to the coal dust having floated on the metal to the walls of the mould, the larger particles being surrounded by a gas film which prevents the metal from forming a true surface.

Core sand should be porous, yet strong enough to withstand quick pouring of moulds with hot iron. Heavy-oil binders giving off a gas should not be used. The metal sets so quickly in the mould

that if any agitation takes place there is very little hope of recovery, especially if the casting is thin or the core is near the surface with metal between.

If the metal blows off a core in grey-iron, the holes usually are on the surface above the core or at the highest part of the casting. In malleable iron the holes are in most cases near the core, the gas being trapped in the metal before it can get to the surface. Malleable castings which, when tested by hitting the surface of the casting with a hammer, appear quite sound, sometimes give startling surprises in the machine shop.

Fig. 11 is quite a simple casting to produce in the ordinary way of foundry work. This casting was made in malleable iron to withstand a pressure of 300 lbs. per sq. inch. At the initial stages of the work it was found that slight leakages took place at *a* and *b*, when the pressure reached nearly the 300 lbs. on several of the castings, which appeared quite sound. After investigation had been made it was discovered that the metal at *a* and *b*

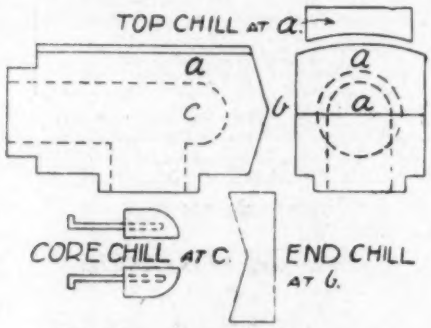

FIG. 11.

was in a plastic state, when the other parts of the casting had reached the freezing point. This caused the structure to separate, owing to the contraction set up by the parts with the lowest temperature, causing a strain at the thickest part of the casting, which at that period gave the least resistance. The only remedy in this case was to lower the temperature of the metal at that point by the application of a chill. Two experiments were carried out, one by having the end of the core made of a split chill, and the other by applying a chill *b* at the end of the casting. In both instances this was effective.

The chill in connection with grey-iron work is generally used to prevent porosity or to give a wearing surface at some particular part of the casting. The chill is used in malleable-iron work to get, as far as possible, uniformity of temperature through the metal when in the mould.

If a number of castings are made in one box, the use of chills is in some cases more economical than risers, owing to the amount of metal needed for the risers to prove effective.

There has been much controversy from time to time round the question of chills and risers in malleable-iron production. Many comparisons have been made, but no definite stand can be taken as to the efficiency of either, as it entirely depends upon the type of casting being made. In some instances it is a decided advantage to use both chills and risers on the same casting. The chill at c (Fig. 11) in the core was an experiment, and successful.

Melting.

There are several methods used for melting iron for malleable-iron castings—crucible-furnace, tilting-furnace, air-furnace and ordinary cupola melting. To produce castings of a high standard the cupola should not be used. While the metal can be controlled in the crucible or air-furnace method, the metal melted in a cupola cannot be controlled to the same extent, and should only be used for castings of an ordinary type. For cupola-melting the metal should be graded into regular charges for the furnace. Good results can generally be obtained by mixing grey with white iron in proportions to produce white castings. The pig varies so much that it is necessary to break it into small pieces to get the required selections for melting.

The metal should be melted as quickly as possible, and tapped very hot into a receiver or large ladle, which will give a better opportunity to get the required mixture from the cupola. In most "malleable" foundries the castings are small, and there is risk of failures if the metal is on the dull side. Castings will appear with round edges and holes. It will be seen that only the best coke should be used to produce a high temperature for quick melting; and there is danger of carbon and sulphur absorption by the metal when melted with badly-burned coke.

Annealing.

The castings are heated in red oxide of iron—hematite ore in varying proportions of ore that has been used before in the oven and new ore mixed. The annealing of malleable iron consists of heating a suitable iron to the necessary temperature and for a time determined by the shape and weight of the castings, to change the character of the metal, both physical and chemical, by removing part of the carbon and throwing the remainder out of combination with the iron, leaving it finely divided in the mass of ductile metal.

The preparation of the castings for annealng known as "packing," can only be done by a man skilled in the work. Considerable care has to be taken during the process to prevent distortion of the castings. When the annealing oven has reached the full temperature the castings can with very little pressure be put out of shape. Indifferent packing may result in the weight of castings above settling down on castings below and causing distortion at some part that is required true to shape.

The most economical and effective way of packing castings is to build up layers of castings, the large ones being securely rammed round with ore and isolated from the others, and if convenient the small castings being packed in the centre of large ones, embedded and separated in the ore. The packing rings should be luted at the joints with wet sand as they are being built up towards the roof of the oven. When the last ring is packed a piece of paper is placed over the packing and wet sand placed over the top of the paper. The packing rings should not be built too high in the oven as the gas is required to travel to the roof, meet and pass down, enveloping the whole tiers of castings and thoroughly saturating them with a uniform temperature. If this is done, and the

castings are packed sufficiently securely, results will prove satisfactory from an annealing point of view.

When the castings are removed from the ovens the packing ore should be thoroughly screened to remove dirt and small broken ore. There is a large amount of sulphur taken up by the packing, which is due to the absorption of sulphur from the gases in the oven. The pyrometer can be used with success to determine the temperature of the oven at any given time during the operation of annealing, but to keep the temperature constant over a given period requires thought and skill from the oven attendant. During the annealing the interior of the oven is closed from all exterior draughts, in order to produce as far as possible a reducing atmosphere. The draught is controlled by dampers, and needs constant attention. The subject of "malleable" is introduced into this paper to indicate the extra labour and care required compared with usual foundry work, to produce a casting of a simple design and little weight.

The Magnetic Sclerometer.

Mr. L. W. Wild has read an interesting Paper before the Faraday Society, on the magnetic sclerometer invented by him, from which we print the following abstract:—

Specimens are constructed in the form of rods 3 in. long and ½ in. in diameter. These are given various heat-treatments according to the nature of the problem it is desired to investigate.

The method of testing is as follows:—The specimen is placed inside a solenoid and the magnetic circuit is completed by the addition of yoke pieces of soft iron. A direct current of sufficient magnitude is flashed on to

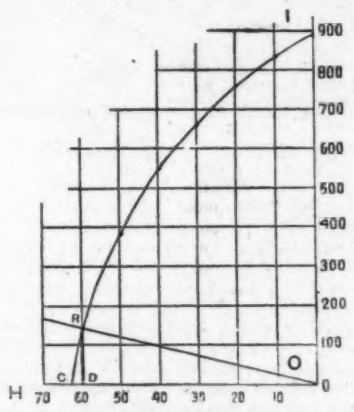

Fig. 1.

the solenoid to saturate the iron completely. The specimen is then withdrawn from the solenoid and placed in a small search coil connected to a Grassot fluxmeter. The throw of the needle of this instrument indicates the amount of magnetic flux still remaining in the specimen.

When the specimen is of the dimensions indicated, the flux remaining and registered, is strictly proportional to the coercive force of the steel.

The method has been used for the investigation of the following problems:—(1) Determining the best conditions for annealing iron and mild steel. (2) The determination of the critical refining temperature of mild steel. (3) The determination of the best hardening temperatures for alloy steels. (4) The effect of overheating carbon tool-steel, and the conditions required to restore to its best condition steel that has been overheated. (5) The effect of the addition of various substances to quenching water and the effect of raising the temperature of the quenching medium. (6) The comparison of the quenching power of various oils. (7) The effect of tempering to various temperatures, more especially on alloy steels. (8) The approximate analysis of steel in general.

The Paper contains details of many of these tests. The diagram, Fig. 1, explains the theory of the method. The line I C represents the demagnetising curve of a specimen of tungsten steel. O C is the coercive force, O D is the demagnetising force due to the poles. O R is the demagnetising coefficient. The slope of this line is determined by the ratio of length to diameter of the specimen and is the same for all steels, without regard to their physical condition. The line R. D. is the quantity of magnetic flux that actually remains in the specimen after it is removed from its yoke. This is the quantity actually measured by the fluxmeter. Obviously R D is proportional to O C, provided that the specimen is sufficiently short—

O D = 0.415 × R D (Prof. Silvanus Thompeon).

O C = 1.05 × O D (Wild).

With a fluxmeter scaled in units of 10,000 Maxwell turns, the instrument becomes direct reading in terms of C.G.S. units of coercive force, with a winding on the search coil of 275 turns.

Banking the Cupola.

A writer in a recent issue of "The Foundry" remarks that banking a blast furnace for a month or two is fairly common practice. Cupolas have been banked also, but from the nature of conditions which prevail in a foundry they have never been banked for any extended period of time. A recent experience may prove interesting to foundrymen who are doubtful how long a cupola can be held and still give satisfactory results. The case is not conclusive by any means, but it proves that a cupola may be held for at least 18 hours without detriment.

The experiment was tried with a 72-in. cupola at the plant of the Kilby Manufacturing Company, Cleveland. On this occasion the furnace was charged in the usual way with a coke bed of 3,600 lbs. and 4,000 lbs. of iron. This was followed by six alternate layers of 400 lbs. of coke and 4,000 lbs. of iron. When filled to the charging door, the cupola had a capacity of 12 tons of iron. Charging was finished at 1.30 p.m. and the intention was to put on the blast at 2.30 p.m.

When the melter attempted to start the blower motor, the starting box blew up owing to a short-circuit. The damage was so serious that casting was out of the question for several hours. We were confronted with the alternative of dropping the bottom or holding the furnace until the following morning. It was decided to adopt the latter course. The furnaceman was instructed to close the tuyeres and the gate in the blast pipe in order to prevent any air from reaching the fuel. Repairs to the starting box were effected during the night and the blower was started at 7.30 next morning. In about five minutes the iron came down, as hot as usual. The remainder of the iron, 28 tons in all, was afterwards charged in the regular way and came through as readily as if there had been no delay.

Research Work on Malleable Cast-Iron.*

By Enrique Torceda.

Extract.

This paper contains an account of four years of research work undertaken for the American Malleable-Castings Association as a plea for industrial research among manufacturers and as a striking example of what such research can accomplish. The author outlines the organisation and purpose of the Association, and shows how the quality of the product of its members has steadily increased since the beginning of the research work. Malleable-iron castings, due to lack of uniformity and dependability, were rapidly being replaced by other materials. There were many fallacious ideas and theories regarding the physical properties of such heating and the methods of annealing them. Records of tests of 1-in. bars from seven different concerns made by the author in 1911 showed that the average ultimate strength was 39,882 lbs., and the elongation under 5 per cent. A report dated March, 1919, to the members of the Association, each of whom regularly submits test bars from some one heat of each day's run, showed that 44 per cent. of the test bars submitted during that month had an ultimate strength over 52,000 lb. and an elongation of 14.67 per cent., indicating the progress made since research work was undertaken.

The records of tests also show that, contrary to generally accepted theory, the elongation increases with the ultimate strength. The purpose of the Association, however, is not to increase ultimate strength and elongation, but to increase the uniformity of a product upon which the engineer can rely, and this is being accomplished through exhaustive research and advice to members through the consulting engineer of the association.

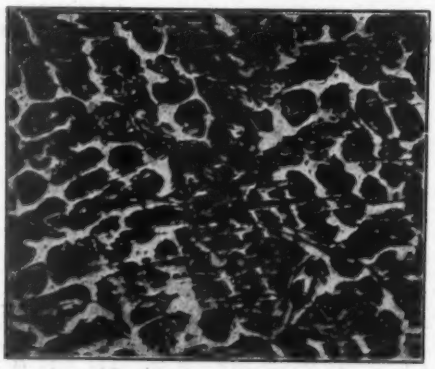

FIG. 1.—SHOWING STRUCTURE OF CARBIDE OF IRON.

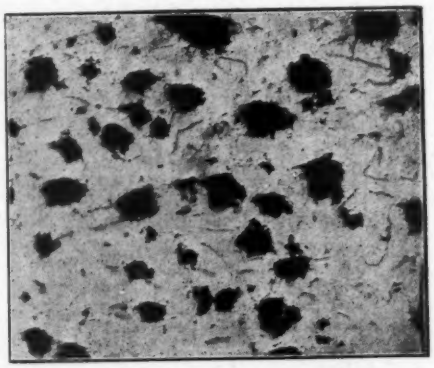

FIG. 2.—WELL-ANNEALED MALLEABLE IRON.

Process of Making Malleable Castings.

The process for making black-heart malleable castings involves two steps. The first step consists in making a casting in which the totality of the carbon will exist as carbide of iron, when the iron will have a structure shown in Fig. 1. (Air-furnace white iron has an average carbon content of but 2.40 per cent. as against an average of 3.50 per cent. in white pig iron.) The casting produced is white in fracture, hard and as brittle as glass. The second step consists in subjecting this white-iron casting to a heat-treatment such as will serve to break up this hard carbide into its two original components, graphite and iron, both of which are very soft. Hence from a white-iron casting we can obtain through heat-treatment one that possesses the properties of strength, toughness and ductility. Fig. 2 shows the structure of a normal well-annealed piece of malleable-iron. The white ground mass is the carbonless iron (ferrite), while the dark continent is the carbon that precipitated out during the anneal. If Fig. 2 be compared with Fig. 1, an idea will be gained of the profound change effected in the structure during the annealing process.

The air furnace in which the white iron is melted, consists essentially of a fire-grate, hearth and stack. Some furnaces have a solid roof, the charge being "pealed in" through the charging-door, but in the larger number of cases the roof is made up of bungs that can be removed during repairs and a sufficient number of them lifted off when necessary for the purpose of admitting the charge. While a few of the furnaces operate with natural draft, most of them use a forced draft of from 3- to 4-oz. pressure. Although oil is advantageously used for fuel in a few instances where its cost is not prohibitive, bituminous coal having a volatile combustible of from 25 to 35 per cent. is the heating agent used by the majority. In order to burn the volatile products of the coal, as well as the CO generated from it, when, as should be the case, a deep bed of coal is used, secondary air is admitted through a series of tuyeres or a continuous tuyere located far enough in front of the grate bridge wall, and so inclined that the air will enter and be deflected about 15 in. from the base of the bridge. In this manner a maximum temperature of about 2,800 to 2,950 deg. Fahr. can be eventually obtained. Con-

* Presented at the Spring Meeting, Detroit, Mich., June 16 to 19, 1919, of the American Society of Mechanical Engineers. The paper is here printed in abstract form, and is subject to revision. Copies of the complete paper may be obtained at a nominal cost.

siderable time and thought have been expended in an endeavour to see if it would not be possible to regulate the amount of secondary air to just insure perfect combustion by the use of a CO_2 recorder, but it was found that the recorder would not act with sufficient promptness. The furnaces vary in capacity from about 7 tons to 35 tons. The best are very inefficient, and in practice the fuel-ratio is about three of iron to one of coal. The average practice does not exceed 2.5 to 1. In numerous cases waste-heat boilers are used, and while this conserves heat, it obviously does not add to the furnace efficiency. The average furnace has a capacity of about 15 tons.

Annealing of Hard Iron.

When a piece of air-furnace hard iron is gradually heated, many of its properties are changed. It will cease to be magnetic, and the size of the crystals will be much finer than was the case under this particular temperature. It can be carburised beyond its original carbon-content if packed in a carbonaceous material and held at this temperature for a sufficient length of time, while if packed in material that yields oxygen it can be decarburised almost completely if the piece is thin. Also the carbide of iron can be broken up into its two soft constituents at this "critical temperature," or critical range, which, for air-furnace hard-iron castings, is in the vicinity of 1,440 deg. Fahr. It is the lowest temperature at which hard-iron castings may be successfully annealed. This statement must be modified by the further statement that in an oven under perfect control this temperature is the one that would be selected. In practice it would not be safe to adhere too closely to it, for the reason that should the castings, while being held "at temperature," fall under the critical range, it would undo in large measure what had been accomplished above it. In the annealing of the castings one of the things to be avoided is oscillating temperatures, or alternating above and below the critical range. For this reason it is necessary to select a temperature some 100 to 150 deg. Fahr. above the critical, say, 1,550 deg. Fahr., in which event, even if due to carelessness the temperature does drop a little, it will not be liable to fall to a dangerous point. There is another reason why this latitude is deemed essential, and this has to do with the fact that in large ovens it requires considerable ingenuity to arrange flue-openings, draughts, etc., in such a manner that the temperature in all parts of the oven will be uniform, for which reason it is necessary to make sure that the temperature of the coldest corner is somewhat above the critical range, which will serve to safeguard oscillations in these locations.

Preparations for Castings for Annealing.

In order to anneal the hard-iron castings that have previously been barreled, or sand-blasted, chipped, gates ground off and inspected, they are packed in cast-iron pots where they are surrounded by an oxidising packing. The packing has a dual function; to furnish oxygen through whose agency the castings will be decarburised to the extent that is possible, and to avoid kiln-warp—that is, prevent the castings from distorting. The usual packing consists of a predominating proportion of inert material, such as ground air- or blast-furnace slag, pulverised firebrick, etc., to which has been added iron oxide in some form, such as rolling-mill scale, hammer-scale, etc. The pots, or stands are sectional, and each comprises a casting which forms its bottom upon which four or five sections are superimposed. Each section consists of a rectangular or circular ring about 1½ in. thick, and varying in size at different plants, depending upon the dimensions of the castings to be annealed, but averaging, if rectangular, about 14 in. by 24 in. by 14 in. high. In building up a high stand a ring is placed on the stand bottom, and then carefully filled with castings that are surrounded with packing. When the ring is completely filled, it is hammered on the sides with a light sledge, in order that the packing will run down and fill in all voids. The second ring is then placed upon the first one, and this is filled in the same manner, which procedure is followed until the stand of four rings is completed. The top ring is filled with castings only to about two-thirds of its height, for if they were brought to the top they would be exposed to the oven gases. Instead, the top third of the ring is filled with packing, and this in turn is covered with an iron plate. The top, and all joints in the stand, are then mudded or luted in order to prevent the entrance of the oven gases, after which the stand is lifted up by the charging-truck and placed in position in the oven.

The annealing-ovens are usually of rectangular shape, and vary in capacity from 15 tons for a very small oven to 50 for the largest ones. Their average capacity is about 25 tons. The usual fuel is bituminous coal, but hard coal, powdered coal or oil are used. These ovens are being standardised and designed with a determination of securing uniformity of temperature throughout. The flues are not only being properly proportioned for the draft used, but the flue openings so dimensioned that the heat can be drawn to any part of the oven in amounts sufficient to equalise temperatures, while provision is made whereby they can be easily kept clean. In the plants of the Association practically all the ovens are under pyrometer-control, and equipped with a central station where it is possible at any moment to ascertain the temperature at the hottest and coldest part of any oven, while a master pyrometer is used as a check on those that are permanently located. Air-furnace and annealing-oven operations have also developed from extremely crude methods to intelligent control, and this in large measure accounts for the improvements in the uniformity of the product.

Length of Annealing Time and Temperature Limits.

In annealing, the castings are brought "to temperature," that is, to 1,550 deg. Fahr., or as high as 1,600 deg. Fahr. if thought best, as rapidly as it is deemed they can absorb the heat. Too great a forcing of the heat during this period is avoided, for if it is done the rings expand much more rapidly than the material within them, thus leaving a space between the ring and contents allowing the packing to bleed down from the top toward the bottom of the stand, lessening the compactness in the upper rings. In average practice it takes about 48 hours for the oven to arrive "at temperature." The temperature of anneal is then maintained for a minimum of 48 hours, the time recommended being 60 to 72 hours. Firing is then stopped and the oven sealed tight in order that the castings will not cool faster than from 8

to 10 deg. per hour while passing through the critical range. To safeguard this very important detail, this rate of cooling is maintained until the pyrometers indicate that the oven temperature is less than 1,100 deg., for, on cooling, the castings are liable to be some 200 deg. higher than indicated by the pyrometer in the oven. After the temperature has been lowered to that point an opening is made in the front of the oven in order to allow it to cool more rapidly, for the reason that once the castings are at a temperature under the critical range no change can take place in their structural composition, so the only remaining precaution is to see that the castings do not cool so fast that internal strains can develop in them. From the foregoing, it can be readily seen that the average length of anneal ocupies about seven days.

From theoretical as well as practical considerations the writer does not believe that there is a possibility of safely lessening the time for this operation by much more than one day without taking chances. He has designed an oven in which the temperature of 1,600 deg. can be easily attained in 25 hr., and he is aware that when the composition of the hard-iron castings is such that the hard carbide is in its most unstable condition that even less than 48 hr. will suffice for the precipitation of the carbon, so that these two periods can be reduced somewhat, but danger is

FIG. 3.—FRACTURE SHOWING WIDTH OF DECARBURISED RIM.

ever present if liberties are taken with the cooling through the critical range. In order then to safeguard the consumer as well as his own reputation, the manufacturer should make no serious attempt to shorten the anneal unduly. The annealing capacity should be such as to make the attempt unnecessary. If it is made, however, then the pyrometer element should be inserted directly into the centre of the pot, placed for that purpose in contact with the side-wall of the oven, in order better to determine when the castings have actually arrived "at temperature" and the moment when he can commence to record the time the temperature can be started on its downward course, which procedure will enable him to operate more closely and accurately.

From what has preceded it should be evident that the second step in the manufacture of these castings should not be known as an annealing process, but more appropriately as a conversion process. The dominant function of an anneal is to obliterate course crystallisation or an unsuitable one, and replace it by the most suitable that it is possible to produce in the object treated, and incidentally remove internal stresses. Annealing does not imply structural changes in the piece when cold, aside from grain-size and grain-refining. In the annealing of malleable-iron castings the dominant object is to convert white, hard iron, in which all of the carbon is combined, into a soft, tough, ductile iron in which no part of the carbon is in that state. In order to achieve this it is necessary to maintain for a sufficient length of time a temperature just in excess of the critical range, which, as has been pointed out, coincides closely with that at which grain refining occurs, so it happens that during the conversion both objects can be practically attained.

Appearance of Fracture of Test Pieces.

It requires an extended experience before one can tell from the fracture of the iron what may have caused its abnormal condition, which is one direction in which great progress has been made. When a normal, well-annealed piece of malleable iron is subjected to a steady, direct pull in a testing-machine, a point is reached at which the crystalline grains of which it consists are elongated permanently, the stretch continuing until fracture takes place. If the fracture is examined it will be seen that the grains have elongated into finely pointed spines which give what is called a "tooth" to the fracture. When light falls obliquely on such a fracture, there is produced a play of colours that yields a sheen caused by a reflection from the points and sides of the spines and the shadows that

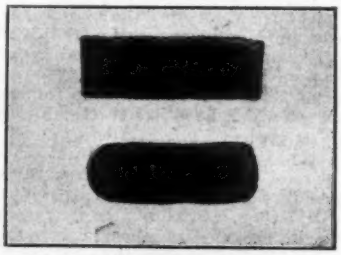

FIG. 4.—PICTURE-FRAME FRACTURES IN LOW-SILICON-CARBON-MANGANESE SPECIMENS.

fall between them. As the grains in the decarburised rim are more ductile than the rest of the metal in the section, they will elongate to a greater extent, and if the fracture is held in certain directions to the light, the width of the decarburised rim can be seen by contrast, its colour appearing under those conditions a little lighter than the rest of the section. (See Fig. 3.)

This explanation is made and entered into because such a rim or border must not be confused with and mistaken for the character of fracture that has a well-defined frame, that is, a border having not only a sharp line of demarcation between it and the core of metal which it surrounds, but an appearance wholly distinct from it. If the writer were asked to pass judgment as to the quality of a piece of malleable iron, based upon either the appearance of its fracture, or what would be shown by a polished and etched section under magnification, he is positive that he could render a more reliable opinion in the case of the former than would obtain in the case of the latter. The reason lies in the fact that even in a non-ductile product it is possible to have an absolutely normal structure, one which consists of a matrix of ferrite or carbonless iron; throughout which are uniformly distributed nodules of free carbon, such as shown in Fig. 1, while if the fracture is as has been described, a normal structure at least can be predicted. If the ferrite is not ductile, then the crystalline grains will not elongate, with the result

that we obtain a structural appearance that would be interpreted by those not familiar with the facts as belonging to a piece that had been insufficiently annealed. It has already been stated that when the silicon is too low a steely fracture will result, and also that the metal is liable to be unsound. In making this statement the writer is assuming that the silicon is low, not because too little was used in the charge, but due to excessive elimination in the air-furnace. In such cases the low silicon will be accompanied by low carbon and manganese.

Picture-Frame Fractures.

Very frequently certain low-silicon-carbon-manganese compositions will yield what are known as picture-frame fractures, such as are shown in Fig. 4, which are typical and have the following composition: Silicon, 0.54; phosphorus, 0.162; sulphur, 0.053; manganese, 0.108; total carbon, .This piece when polished and etched showed the following characteristics: A decarburised surface border, an inner ring of coarsely laminated pearlite, and within this a core corresponding in structure to that of normal malleable iron. It is the presence of this ring of pearlite whose ductility is so much less than that of the metal in ground off of one side of hard-iron samples and upon annealing the frame was in evidence equally on all sides. It is believed that the following facts are pertinent to the situation: Not only do certain compositions affect the ductility of ferrite, but the same is the case with a pearlitic structure. We can have ferrite that will elongate into very long spines and ferrite that will fail to elongate at all. We can have a pearlitic grain that can be ductile and those that are not. The foregoing is stated because the writer believes that whether or not a frame will be produced in the fracture depends upon the breadth and ductility of the pearlitic ring, because a slight pearlitic ring can be present within a decarburised border without a picture-frame fracture being produced. It is his belief that whether there will be a pearlitic ring or not depends upon the rate of surface-decarburisation, as compared with the rate at which a dissociation of the cementite takes place. When conditions are such that there will exist a region between the decarburised-surface border and the core that will have a carbon-content of about 0.90 per cent., equilibrium seems to be established in this region, and if any carbon passes from this region to the decarburised border it is replenished by carbon from the core.

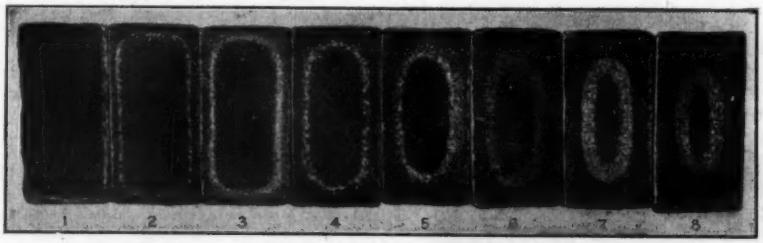

FIG. 5.—THE PEARLITE RING IN SUCCESSIVE STAGES OF ANNEALNG.

either the decarburised border or core that produces on fracture the sharp line of demarcation between frame and core. While in this particular fracture the frame is fiery bright and finely crystalline and the core black, there are picture-frame fractures that show various colour characteristics of frame and core, but it will be found that invariably the frame has its pearlitic ring of greater or less breadth. The pearlite is not always coarsely laminated, but, as a rule, has the appearance and consists of an amount of pearlite that would correspond to a 0.35 per cent. or 0.45 per cent. normalised carbon steel.

If the sulphur in the hard iron is unduly high and particularly if not well balanced by the manganese, the castings will almost invariably show a "picture-frame" on the fracture, and especially is this true if the temperature of anneal is too high for such a composition. If the manganese is too high and not well balanced by the sulphur, the same result will follow. While space is not available to enter into a full discussion of what has been discovered in regard to picture-frame fractures, there are some points that can be recorded. There are some compositions that unquestionably have frame-producing tendencies. These compositions will not produce a frame when annealed in an atmosphere that is not oxidising. The surface structure of the hard-iron has nothing to do with the problem; the writer has had ¼ in.

The Pearlite Ring.

The writer believes that such is the case, and is of the opinion that perhaps the samples shown in Fig. 5 may have a bearing on the case. A well-annealed bar was cut into eight pieces. A section from the first piece was polished and etched, and the other pieces all packed together and given another anneal. The second specimen was then prepared like the first. The remaining six were then given a third anneal, and the third piece polished. As this procedure was continued, it follows that the eighth bar had eight separate and complete anneals. It will be noted that its very faint pearlitic ring which shows whitish and very faint in the once-annealed bar, is very distinct and well defined in the second and that it is wider and further in toward the centre. It will be seen that with each anneal the pearlitic ring has widened and has a smaller periphery. As it was found that with each anneal the total carbon-content decreased, it is plain that once the pearlite ring has formed, it does not act as a seal for the passage of carbon from core to surface, and that the width of the pearlitic ring is built up and added to more quickly from the core than it is robbed of carbon by the decarburised border. The matter can be summed up as follows: If conditions are such that a region containing about 0.90 per cent. or less carbon is formed, this region, while

permitting carbon to migrate or diffuse through it will at the same time be incapable of having its carbon precipitated. Under proper conditions the region can alter its position and increase in extent. For such a region to have a start it is essential that there be a very substantial difference in carbon content in two parts of the section.

Structure of High-Strength Malleable Iron.

Malleable cast-iron of very high strength accompanied by a ductility that can be considered good enough for certain purposes, has already been mentioned. While no effort has been made to exploit this product as yet, it would appear to the writer that there is a very large field in which it could be used to advantage. This material can be made with uniformity, and it is believed from experiments that have been under way for some time that a 90,000 lbs. ultimate and a 10 per cent. elongation might be uniformly maintained. The structure consists of a ground mass of pearlite, in which are more or less uniformly distributed nodules of temper carbon. The structure readily explains why the product is of high strength.

Effect of Heating Malleable Cast-Iron.

As it is frequently necessary to heat the finished product for the purpose of straightening it, for galvanising and other purposes, it may prove instructive to see what happens when an annealed piece of malleable iron is heated up to and beyond the critical range. Ten pieces were cut from a normal, well-annealed bar. The pieces were then placed in an annealing oven that could be

FIG. 6.—BAR MAGNIFIED SEVEN DIAMETERS TO SHOW CARBON DISTRIBUTION.

controlled with great accuracy. When the pyrometer registered 1,250 deg. Fahr., one piece was withdrawn and allowed to cool in the air. When the temperature reached 1,300 deg. Fahr. another piece was withdrawn. The other pieces were withdrawn at temperatures of 1,350, 1,400, 1,450, 1,475, 1,500, 1,550, 1,600, and 1,675 deg., respectively. An examination showed that increased amounts of pearlite resulted as the temperature was increased, and nearly all of the temper-carbon had been dissolved. It follows that for straightening, brazing and other operations that necessitate the heating of a malleable-iron casting, the temperature used should be well under 1,400 deg. Fahr.

Common Fallacies.

The fallacies that have been handed down and accepted by many of the engineers and consumers as true are numerous, but the following only will be touched upon, as they are the most important:

(*a*) The strength of malleable-iron lies in the skin. When it has been removed the remainder of the metal is found to be very inferior and not dependable.

(*b*) During the anneal, the elimination of the carbon is confined to the surface, and the amount removed from the rest of the section is inconsequential.

(c) When the section of a casting exceeds ⅝ in. in thickness it cannot be annealed throughout.

Concerning item (*a*), the data in Table 1 will prove of value.

TABLE I.

Mark.	Ultimate strength, lb. per sq. in.	Per cent. elongation in 2 in.
12-2-1	52,084	17.50
12-3-1	47,182	10.00
12-3-2	51,107	17.50
12-4-1	56,732	14.00
12-5-1	46,482	17.00
12-5-2	52,246	23.00
12-6-1	47,889	19.00
12-7-1	48,080	18.00
12-7-2	49,640	18.00

Nine regular test bars were machined until the decarburised surface was removed. These bars were all from different heats and marked as indicated in the table. It is obvious and must be acknowledged that the metal in the decarburised-skin is more ductile than the core, so when a bar fails it must be conceded that it is the core that has parted first, for the reason that the metal in the skin has not at the instant of fracture reached its maximum elongation. Aside from the foregoing we have the practical evidence that presents itself in the case of the automobile industry in which thousands of tons of machined malleable-iron castings are used annually on parts that receive in service great abuse, such as wheel-spindles, etc. On the other hand, the writer not only admits that when the skin of some malleable-iron castings is machined, the remaining part is worthless, but admits as well that the castings would be such with the skin on. This, unfortunately, will continue to be the case until the purchasing agents cease to shop around and make contracts with price as the basis rather than quality.

Taking up item (*b*) the writer can, without encumbering this paper with the large amount of data he has on the subject, prove the falsity of this contention. In the figures quoted in the complete paper, for bars of over 52,000 lbs. ultimate strength and over 20 per cent. elongation, there are two bars, one of which has a carbon content of 0.72 per cent. and the other of 0.82 per cent. Apart from this there are fourteen with a carbon content of 1.50 and under. It has already been pointed out that the carbon in the hard-iron must be kept up to a certain figure, failing which the castings will not only be difficult to run, but contraction-cracks will spoil them. If we assume, in the case of the first two bars referred to, that the carbon was reduced by one-half, then in the bar that had but 0.72 per cent. carbon, the carbon in the hard-iron from which it was cast must have been 1.44 per cent., and we all know that it would be almost

impossible to run such work, to say nothing of subsequently annealing it. In a ⅛-in. diameter annealed bar such a low carbon content is unusual, but it proves the point that is being made, nevertheless. The writer has polished the section of two ⅛-in. bars and has photographed them at about seven diameters. One of these is shown in Fig. 6, and will furnish an idea as to how the carbon is distributed throughout the section, and indicate that the carbon does not vary by uniform gradation from surface to centre, but in one region can vary slightly from what it may be in another. This does not signify that in the regions of highest carbon content the carbon has not been lowered through diffusion into its contiguous region, for many investigations have shown that this is just what does happen.

Item (*c*) can be disproved in a few words. We know that in order to break up the hard carbide in white-iron it is simply necessary that the casting be not only heated until the iron is in an austenitic condition, but maintained at that temperature for a certain interval of time. To state that thick castings of white-iron cannot be annealed is to state that they cannot be brought to a uniform temperature throughout and maintained at that temperature. Such a claim would be an absurdity.

For the benefit of those who labour under the impression that malleable iron is a product unsuited for any but small castings, the writer would say that he has a photograph of a casting 5 ft. long, 23 in. high, with some of the sections 3 in. thick. The metal when well made, can also withstand great abuse. Irrespective of how good the metal may be, as shown by physical tests on bars and wedges, patterns are often furnished so outrageously out of proportion that the good qualities of the metal can easily be destroyed and too frequently the metal is blamed when the design is at fault. These troubles are overcome as far as possible by a thorough study of the best method of gating the casting, in order that no evidence of shrink may be present in any part. Research has made considerable advance in this direction and well-placed, well-proportioned shrinkage heads are now generally used. Not infrequently, in the case of such castings as the ones referred to, the sprue, runners and heads weigh about as much as the casting.

SYNTHETIC CAST IRON.—This is the name given in France to castings produced in the electric furnace from steel scrap, with suitable additions to increase the carbon content of the metal. According to M. Pinot the process was extensively used in France for making shells, the monthly output since the middle of 1916 having been 7,500 tons. A Paper was read on the subject at the recent annual meeting of the Iron and Steel Institute.

ANALYSES OF AMERICAN HIGH-SPEED STEELS.—Mr. Edward W. Rettew, after a careful study of a considerable number of analyses of high-speed steels representative of present American practice found the following limiting percentages (the percentages to be specified as suggested by him being shown in brackets in each case):—Carbon, 0.60-0.70 (0.65); manganese, 0.15-0.40 (0.30); phosphorus, not over 0.015 (under 0.010); sulphur, not over 0.015 (under 0.010); silicon, not over 0.30 (0.20); chromium, 3.50-4.50 (4.00); tungsten, 16.00-18.00 (17.00); vanadium, 0.65-1.05 (0.85).

The Works Manager and the Progress Department.—I.

By William H. Hiscox.

The popularity of the progress system of factory organisation has greatly increased during the past few years, as is evidenced by the fact that the Progress Department is being instituted in the majority of the engineering factories of the country. It may be inferred, therefore, that the importance of this department is generally appreciated, but actually, although the need is recognised, the importance seems to be interpreted by different works managers in varying degrees. Each manager has his own ideas as to what constitutes the functions of the department, and the position it should occupy in the organisation of his factory. In view of the diversity of those ideas, as made manifest in different factories, it is proposed, in these articles, to consider the attitude of various managers towards their Progress Departments, and the ultimate effect of that attitude upon the efficiency of the department.

The first illustration is furnished by the works manager who, forced by circumstances to recognise the need of the Progress Department, grudgingly grants certain facilities for its establishment, but restricts its efficiency and usefulness by insisting upon a personnel of low-rated and untrained men. This manager, who is of a type now happily becoming more rare, classifies his clerical and administrative staff as "non producers," and as such to be remunerated at the lowest possible rate. He has very elementary ideas as to the duties of the Progress man, which he considers are non-technical, and can be performed by a "semi-skilled" man. He derides the notion that a Progress man must be specially trained to perform what is required of him in an intelligent and an efficient manner, and considers that labourers and handy men (providing they are able to read and write) are quite competent to perform the duties appertaining to the Progress Department.

From this it will probably be inferred that the standard of efficiency desired, and the importance of the duties involved, are of a distinctly low-grade character, but such is not the case. The Progress Department, no matter under what circumstances it is established, must of necessity speedily come to grips with problems of the highest importance. Even "chasing," the least technical of the duties involved, presents problems which extend to the trained man, and the manager of the type under review speedily becomes aware of the fact, at the same time attempting to force his Progress Department to undertake duties which, by reason of the low status occupied, and the mediocre quality of the personnel, the department is absolutely incapable of discharging.

One cannot blame the manager for endeavouring to make his Progress Department undertake the duties which come within its purview, for obviously he has no choice in the matter. The quarrel with him is, however, that he either cannot or will not realise that his own policy is at fault, and that as a consequence he is working on totally wrong lines in the endeavour to bring the department to something approaching efficiency. His opinion regarding the class of man required has undergone no change, and he uses his own mediocre Progress Department (which in reality is not a Progress Department at all) as an illustration to prove the worthlessness of the Progress system generally. The manager who is short-sighted enough to attempt to establish a Progress Department on these lines very rarely has the courage to acknowledge his error by reconstructing the department in accordance with more enlightened ideas. On the contrary, he seeks to justify his initial venture, and attempts to "strengthen" his Progress Department, not by the inclusion of experienced men, but by adding

to the personnel what may be termed the "misfits" of other departments. The Progress Department really should be of great service to the works manager, and should considerably lighten his labours, but the department established and conducted in such a manner as the one under review, instead of so doing, on the contrary intensifies his labours. The manager every week wastes hours over matters which, in a well organised factory, would never be referred to him. Numerous foremen's conferences, unnecessary for the most part when the Progress Department is efficiently carrying out its duties, occupy many hours of highly-rated officials' time each week, thus proving that initial cheapness more often than not provokes ever increasing expense, apart from the loss incurred in the failure to increase output.

The works manager's lack of appreciation of the Progress man's duties is responsible for many badly conducted and inefficient progress departments, but it is not only by staffing the department with untrained men on a low rate that this lack of appreciation is made manifest. There is another type of manager who is equally at fault, although from a different standpoint, and this is the individual who, whilst admitting the technical qualifications, still under-estimates the importance of the department. In this case the conditions are entirely different. The department is fairly well organised, and the personnel, if not composed of high-rated men, is at any rate composed of men of a distinctly higher grade than those in the first illustration, by which is meant that business qualifications are taken into consideration. Unfortunately, however, the limitations imposed upon the activities of the department do not permit of its achievements reaching a very high level, which means that, once again, it is a Progress Department only in name.

The officials of this department have what is commonly called a "soft time," which state of affairs does not, however, appeal to the ambitious man. A certain standard is set up, and no attempt is made to rise beyond that standard. The officials are usually dubbed "Progress clerks," and their duties lie in the direction of compiling records, and "chasing" material under the direction of the various shop foremen. The charts and forms are compiled from information derived from the shops, by means of delivery notes, etc., and the onus is upon the shop foreman to inform them when certain material requires chasing. Their work, in the main, consists of "has been" rather than "to be," the shops controlling the Progress Department instead of *vice versa*.

A department of the description given is certainly not a force to be reckoned with in the words organisation, and, as a consequence, its status is very low. It has very few responsibilities, and no authority. It cannot control, for it has nothing to control, and at the best it is nothing but a linking-up department. Even the linking up is governed by the various shop foremen, for, should one of them omit to acquaint the Progress Department of his requirements from another department, then obviously the linking up process falls through. Such a department is of no practical value either to the departmental foremen or to the works manager. It certainly does not accelerate the progress of work through the shops, for the chasing work it carries through could be handled more expeditiously by the departmental staffs. It is difficult to see how any enlightened works manager can tolerate a Progress Department working on these lines, and yet such is the case in some of the largest engineering concerns in the country. The works manager must be held personally responsible, for he it is who fixes the limits to the activities of the department.

The conditions are demoralising; the Progress man has no incentive to improve himself, and seizes any opportunity of transferring his activities to where they will receive recognition. As the standard of importance is limited, so also in like proportion is the standard of remuneration, for there is nothing in the achievements of the personnel of the department which will warrant an increase of salary. Thus ambition is stifled, and this is fatal to the well-being and efficiency of the department.

It will thus be seen that manager number two has not achieved any better result than manager number one; in fact, it may be said that his standard is really lower, for he is literally paying money away for which he gets no return. The departmental foremen still occupy the greater portion of each day with administrative work, which does not tend to improve the facilities for economical production upon which they should concentrate.

Another point of importance to the Progress Department is the support of the management, without which, no matter how highly organised and efficiently conducted it may be, the department cannot possibly succeed. The class of works manager whose attitude in this connection is open to criticism, is more numerous than those in the previous illustrations, and is also more important, seeing that this type of manager realises the need for the department, recognises its value, and sets upon it a very high standard.

It is in connection with the last phrase that exception to his attitude must be taken, for having set the standard, he does not attempt to assist the department to attain it, and the standard being set so high, the department cannot reach it, unassisted. This may appear to be a reflection upon the capabilities of the department, but anyone thoroughly understanding the difficulties encountered in progress work will appreciate the necessity for the backing of the management.

No department in the works organisation is so completely misunderstood, and, consequently, so subject to opposition, as the Progress Department, and when it has been established in such a way as to make its effect felt throughout the factory, then foremen and other high officials begin to realise that it is a force to be reckoned with. They can no longer perform their accustomed tasks in the good old-fashioned way, unchallenged by all save the works manager. New methods of routine are introduced, matters over which they had supreme control are taken away, and they view, first with distrust and then with alarm, the ever-increasing activities of the new department.

For this new department assumes responsibility for delivery and output, and the shop foreman is told what to do, and when to do it. What he is not told is how to do it; that is still his privilege. His chasers and runners are taken from him, being transferred to the new department, and his shop clerks suffer a like fate. He is not grateful for the help afforded him; on the contrary, he resents it, and although powerless to arrest the growing influence, he does all he can to combat it. The foreman in the past was all-powerful. At the present his power has scarcely diminished, and with these wrongs rankling in his mind he is dangerous. It must, therefore, be agreed that opposition from this source cannot be ignored. The Progress Department is not antagonistic to the foreman, but the latter chooses to think otherwise, and against such an opinion the department can do little, except with the support of the management.

The new Progress Organiser often asks for a free hand, and he sometimes gets one decidedly too free. The manager leaves him severely alone, and he has to fight his battles unaided. Here he is at a grave disadvantage, for being a newcomer he naturally is not so conversant with the factory conditions and customs as the old stagers who form the opposition. This opposition is not open; on the contrary, he receives many protestations of assistance, but the opposition is there nevertheless, and the moment it becomes apparent that the management is leaving him to find his own level, that opposition becomes more pronounced. The negative policy is usually pursued in this respect, and the Progress Department has great difficulty in carrying out its duties.

Extensions to the Works of Sutcliffe, Speakman and Company, Limited.

During the war Messrs. Sutcliffe, Speakman & Company, who have had extensive experience in briquetting fine ores, adapted much of their machinery to producing brass stampings for shells. Fuse rings formed one of the chief items of production, of which they made some 35,000,000. The total weight of stampings turned out by the works on munitions account amounted to no less than 17,000 tons. In the early days the necessary extruded brass rods were supplied by the Ministry, but it was not long before they were wholly unable to cope with the demand, and so brass workers generally, commenced to cast their own, melting up for the purpose manly scrap, swarf for the most part only being used when heavy scrap was unobtainable. Brass working being an entirely new industry to Messrs. Sutcliffe, Speakman, there was no brassfoundry at the Leigh Works, or indeed any shop which could be converted to such service. However, their lack of knowledge of the trade proved an asset rather than otherwise, because they were at least able to start free from all prejudice in favour of any process or method of production, whilst they had before them the possibility of the economical utilisation of almost unlimited quantities of swarf. It was at the same time recognised that to melt this swarf would entail a loss of anything from 12 per cent. to 20 per cent. On the other hand, an important factor in favour of the swarf was that a more uniform metal was obtainable (the desideratum being a 60—40), whereas heavy scrap frequently contained a large percentage of castings in which a high tensile strength had not been imperative. The analysis might, and often does, vary considerably with each cast made from such material.

FIG. 1.—SWARF BRIQUETTING PLANT.

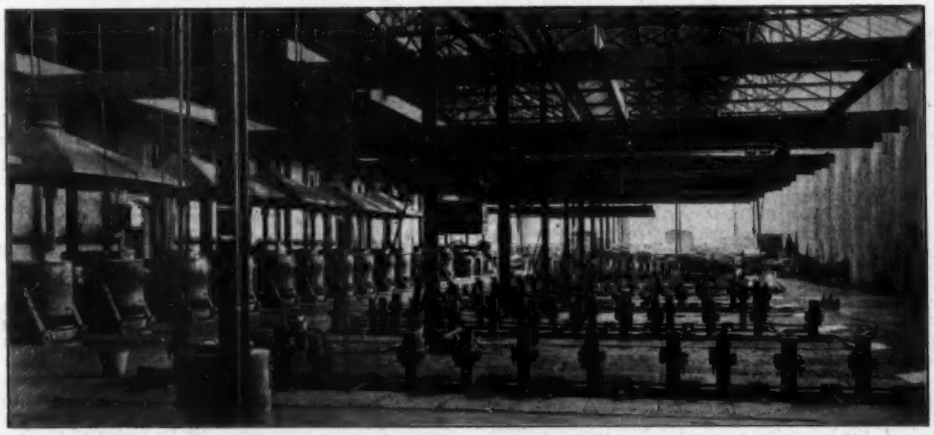

FIG. 2.—VIEW IN FOUNDRY; CHILL PITS IN FOREGROUND; BATTERY OF 400-LB. FURNACES ON LEFT.

Messrs. Sutcliffe, Speakman decided that in briquetting lay the solution of the economical use of swarf. When they had satisfied themselves by practical experiment of the commercial possibility of the process, they took the only available shop in the district—an old weaving shed—and laid down a foundry in which they

produced about 90 tons of rods per week, and in the meantime proceeded with the erection of a new foundry on land adjoining their works. For all practical purposes, however, the brassfoundry and auxiliary shops take the form of an entirely self-contained works.

It will be obvious that it will not be possible to turn to peaceful account much of the plant which has rendered such yeoman service during the war, but for the most part the works lend themselves very readily for conversion to peaceful requirements, being capable of turning out castings from the smallest parts up to almost any weight, and being adapted for the manufacture of any and every class of stampings, or rather pressings, for that is what they actually are, it may be interesting to deal with the works as we find them to-day. As previously stated, they form an independent block of buildings, fronting on to Guest Street, where the offices, laboratory, and test department are situated. The shops are disposed at right-angles to the foundry, which extends for the full width and lies at the rear of the works. The shops are covered by four bays, each 200 ft. long by 30 ft. wide. The swarf is delivered to a platform outside, and extending for the full length, of the first, particularly convenient for a foundry working at high pressure, as being mounted on a trolley base, it is possible to hold a spare, so that when repairs are required the furnace can be removed bodily and the spare put in, thus avoiding the loss of time incidental to effecting a repair on site. In the form of briquettes each pot with its preheater takes the full charge at one operation, and oxidation losses are said not to exceed from 2 per cent. to 3 per cent. Blast for the larger furnaces is supplied by a separate fan. The 16 furnaces are, so far as blast is concerned, worked in two batteries, each from a Keith-Blackman fan. In the method of casting we find another departure from standard practice. For special work it is a universal custom to cast from the first melt into ingots, to take an analysis, and then remelt for casting the billets. In the foundry under notice the content of the metal is a known quantity before it is charged to the pots, and the metal, so soon as it is brought down, is cast direct into ingots. As will be seen from our illustrations, the chills are arranged in pits in front of the furnaces, 27 in a pit with a pathway between each pair, and are served by an overhead telpher. After pouring in, the chills (which are mounted on swivels) are tilted up

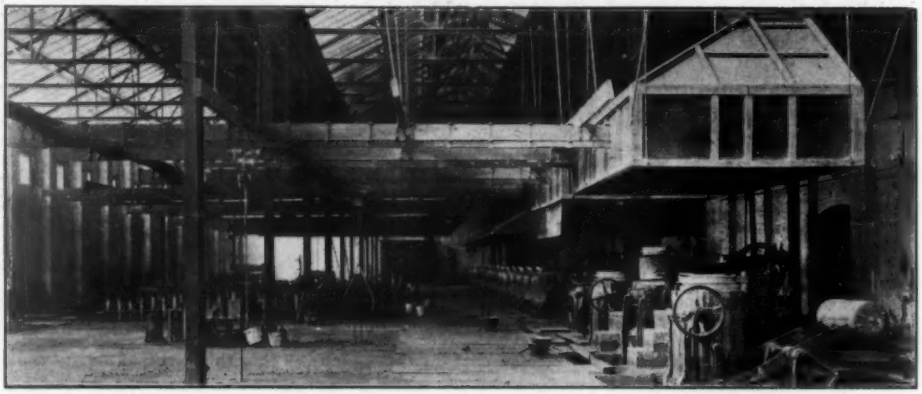

FIG. 3.—ANOTHER VIEW IN FOUNDRY; LARGE FURNACES IN FOREGROUND.

the mixing and briquetting bay. In this bay heaps of swarf of about 60 tons are accumulated and are then thoroughly mixed by hand. From this mixture a sample cast is made and analysed, and thus the quality of the bulk is determined. Perhaps the better way will be to follow the swarf in its passage through the works. After the mixing referred to, it is conveyed in barrows to a runner mill, where it is ground up with the necessary flux and after grinding is put through a magnetic separator, of which two types are in service—the Rapid and the Ding. Each separator is equal to dealing with 1 ton of swarf per hour. The swarf then passes to one of the two Sutcliffe-Speakman briquetting presses, by which it is converted into briquettes. The briquettes average 75 to the 100 lbs., and the output of each press is 1 ton per hour. As they are made the briquettes are piled on the floor and the heaps labelled with the analysis of the particular batch, which has already been determined from the test cast. As required, the briquettes are loaded into boxes, weighed, the required quantity of spelter added, and are then conveyed by barrow to the platform which extends the full length of the foundry immediately at the rear of the furnaces. Upon this platform also are provided bins for the coke, one bin serving two furnaces.

The melting plant comprises a Monometer furnace of 800 lbs. capacity, three Morgan furnaces each of 600 lbs. capacity, and 16 Mathew-Harvey furnaces each of 400 lbs. capacity. These last have been found by a girl passing down the path, the bottom drawn, and the rods pushed out and the bottom restored ready for the next cast. Two double sets of pits will be retained, but the rest of the foundry floor is being made up for casting. At one end of the building the foundations are being got out for an Alley-MacLellan compressor and a complete range of moulding machines is to be installed.

GERMAN TIN SHORTAGE.—A U.S. Commercial Report states that Germany has been suffering from a shortage of tin during the war. Substitutes were used wherever practicable, and everything possible was done to utilise old tin and scrap. Among other expedients a kind of lacquer, consisting of a solution of phenol and cresolin with formaldehyde and alkali, was excessively used. An alloy composed of zinc, cadmium and lead is still being employed as a substitute for tin for various uses. Works have also been extensively engaged in the recovery of tin by means of mechanical, chemical, and even electrolytical processes. Large quantities of tin have been recovered from discarded empty tins, and also from clippings found in old dump heaps. One of the most striking measures taken to secure tin from domestic sources was a proclamation in January, 1917, ordering the confiscation of organ pipes made of tin. Exception was made only in the case of organs declared by duly authorised experts to have special intrinsic or historical art value.

Trade Talk.

In order to carry into effect the amalgamation of the Workington Iron & Steel Company with the United Steel Companies, a resolution has been passed for the voluntary winding-up of the former company.

There were launched from Scottish shipyards during August 32 vessels of 55,386 tons. Of these, 29 vessels of 52,181 tons were built on the Clyde, one of 2,000 tons at Dundee, and two of 1,205 tons at Aberdeen.

The name of the British Westinghouse Electric & Manufacturing Company, Limited, has now been changed to that of the Metropolitan-Vickers Electrical Company, Limited. The certificate of the Registrar of Joint Stock Companies bears the date September 8, 1919.

The Garred-Cavers Corporation have issued licences for the use of their process at the smelters of the International Nickel Company, of Canada, Limited, the Tennessee Copper Company, and the Cerro de Pasco Copper Corporation. In regard to the latter concern arrangements have been made not only to utilise pulverised coal in the existing blast furnaces, but also in a new smelter to be constructed very shortly.

The businesses of F. C. Banister & Company, engineers, Royal Exchange, Manchester, and Coackley & Walton, engineers, Spring Gardens, Manchester, have been amalgamated, and in future will be carried on as Banister, Walton & Company, Limited, 431-433, Royal Exchange, Manchester, and the Constructional Steelworks, Trafford Park, Manchester. The directors are Mr. B. J. Pearce, Mr. F. C. Banister, Mr. P. Walton, and Mr. A. Statham.

The Blyth Shipbuilding & Dry Docks Company, Limited, recently launched from their new shipyard the steel screw steamer of the "C" standard type, built to the order of the Shipping Controller (eventually sold to the Claymore Steam Ship Company, Cardiff). This vessel, which measures 331 ft., with a beam of 46 ft., is specially adapted for the general trade. This is the first vessel to be launched from the company's new yard, which consists of three building berths of 450, 420, and 386 ft. long respectively.

The Lord Mayor has received a letter from Mr. Lloyd Harris, the chairman of the Canadian Mission in London, 1, Regent Street, describing the work of the Mission, which was established here by the Government of Canada to help in the reconstruction of Europe. "Now that the war is over Canada feels that her efforts should be devoted to the development of a larger interchange of trade with the Mother Country. Canada not only seeks to find markets in Europe, more especially in the United Kingdom, but she has considerable markets to offer British manufacturers. The Canadian Mission will give all the information and help in its power to enable British municipalities to secure quotations from Canada for materials which they may require.

The Federation of Civil Engineering Contractors, with Viscount Cowdray as president, has recently been formed, the members constituting practically all the large civil engineering contractors in Great Britain. The main object of this federation is to act collectively, through an elected council, in relation to the professional institutions and public authorities, and to deal with trade unions and other labour organisations in regard to hours of work, rates of pay, and all other matters appertaining to the employment of labour. This latter work must necessarily include a participation in the work by conciliation boards, which may be already constituted or whose constitution is now in contemplation. The secretary is Mr. E. J. Rimmer, and offices have been taken at 40, Broadway, Westminster, S.W.1.

The prospectus of the British Industries Fair to be held in Birmingham, from February 23 to March 5, 1920, has now been issued. The exhibition, which is under the auspices of the Board of Trade, will be held concurrently with those in London and Glasgow, a feature will be that the inspection of samples will be open only to approved buyers, every exhibitor being given the right to refuse entrance to his sample-room in regard to any visitor. For several years a British Industries Fair, organised by the Board of Trade, has been held in London, and during the past three years a similar fair has been held in Glasgow. The Board of Trade has sanctioned the holding of a fair at Birmingham next year. It is pointed out that those who intend to exhibit and apply early will benefit in the process of grouping.

Despite Government assurances, the wire-nail manufacturers in this country who have put down extensive plant during the war, now find themselves undersold. At the present price of wire in this country it is possible to produce wire nails at £30 a ton. The industry, however, claims that, if only time is given and the home market secured, it will be able to reduce costs so as to make it a competitive industry. Americans are, however, able to put wire nails on the market here at about £22 a ton, raw material costing them £18 a ton. This was represented to the Government, and the importation of wire nails has been prohibited except under licence. Now, however, the licensing system has been abolished, the wire-nail manufacturers cannot discover whether they are to be left to the mercy of an open market or protected as a key industry.

The first order under the Profiteering Act, giving a schedule of the goods with which the local committees will have to deal, has been issued by the Board of Trade. The local committees will hear complaints as to the prices charged for these goods. The list of scheduled goods includes building materials, including bricks, hardware and ironmongery, light castings, milled lead and pipes, red and white lead, zinc, copper, tin and alloys, cast-iron pipes, wrought-iron and steel pipes, valves and fittings; electric cable fittings, plant and meters; gas pipes, fittings, plant and meters; tar, structural steel and ironwork, rolled joists, channels, angles, tees, bars and plates, and plant, tools and tackle required for the construction of buildings and public works. The order also applies to any other article coming within this class.

Messrs. G. P. Wall, of the Magneto Steel and Wire Works, Penistone Road, Sheffield, have issued a new steel tempering chart, which, in a measure, is unique, having been reproduced as faithfully as possible from actual pieces of heat-treated tool steel, this being the first time it has been achieved. To indicate the care taken to produce a reliable chart, it may be mentioned that the procedure was as follows:—(1) Steel machined to remove surface scale; (2) steel hardened, then ground bright; (3) one piece tempered accurately to each of the temperatures indicated on the chart, the duration of the tempering process being the same for each piece and the same duration as would be given to the tempering of tools in "Works Practice." For those firms tempering in liquid baths, the tempering temperatures are indicated in both Centigrade and Fahrenheit. Temperatures are also shown for forging, annealing, normalising, and hardening tool steels.

Special interest attaches to a memorandum on import duties and the engineering industry submitted to the Prime Minister by Mr. D. A. Bremner, director of the British Engineers' Association, in view of the public attention now centred in Mr. Lloyd George's statements in regard to the Government's trade policy. The council of the association, at a recent special meeting, passed the following resolution:—"Resolved that the director be and is hereby instructed to inform the Prime Minister that this Council is of opinion that, whatever may have been the merits or defects of Free Trade in the past, the great changes that have taken place in the industrial and economic situation through-

out the world demand a complete reconsideration of the fiscal policy of this country, in the light of the facts and the tendencies of to-day, and that some measure of protection—in certain cases going beyond mere anti-dumping legislation—will have to be provided for the engineering industry if it is to thrive to the extent required to afford any prospect of fulfilling the new standard of life expectations of the workpeople engaged in it.

THE following awards have been issued by the Board of Referees under the Finance Acts (Excess Profits Duty) :—Ferro-Concrete Shipbuilding.—1. In the case of a company, statutory percentage increased to 15 per cent.; in any other case, to 15 per cent. plus 2 per cent.; for the purposes of sub-section (2) of section 41 of the principal Act, 15 per cent. plus 1 per cent.; with the addition of 3 per cent. for the purposes of sub-section (1) of section 41 of, and paragraph 4 of Part II. of the Fourth Schedule to, the principal Act. Supplies of Electrical Energy :—Company, 7½ per cent.; other cases (*a*) for accounting periods ending prior to January 1, 1917, to 7½ per cent. plus 1 per cent.; (*b*) for accounting periods ending after December 31, 1916, to 7½ per cent. plus 2 per cent.; except that for the purposes of sub-section (2) of section 41 of the principal Act the statutory percentage shall be 7½ per cent. plus 1 per cent.; with the addition, in cases 1 and 2 (*b*), for accounting periods ending after December 31, 1916, of 3 per cent. for the purposes of sub-section (1) of section 41 of, and paragraph 4 of Part II. of the Fourth Schedule to, the principal Act.

SINCE the armistice, Messrs. Sir W. G. Armstrong, Whitworth & Company, Limited, have largely extended their plant and scope for the manufacture of new types of A.W. pneumatic tools. A portion of the works at Elswick has been devoted to this purpose. Armstrong-Whitworth have, of course, been manufacturing pneumatic tools both for their own use and for others for many years past. They have consequently acquired considerable experience with tools of this nature, which have given long service under severe conditions in their own workshops and shipyards. The new A.W. pneumatic tools now being placed on the market are light and heavy hammers for riveting, chipping, caulking, holders-on, sand rammers, etc. They claim very simple design, simplicity of valves, a considerably heavier and quicker blow for the same weight of hammer, very little vibration, low air consumption, interchangeability, and durability. In addition to the ordinary chisel blanks and rivet snaps, Armstrong-Whitworth make a non-tempering steel (P.N. brand), and also a shock-resisting chrome vanadium steel (C.V. brand), suited for pneumatic toolwork.

OBJECTION to the removal of import restrictions on firearms, cartridges, and component parts thereof, is taken by members of the Birmingham Gun Trade. The secretary to the trade (Mr. A. A. Edwards) has addressed a letter to the Controller of Import Restrictions, Board of Trade, in which he calls attention to the anxiety which the decision to remove the prohibition has caused members of the trade, and points out that during the past five years the Birmingham gun trade has been entirely closed down, and the industry which has always suffered from the burden of restrictions, has especially suffered from the fiscal policy of the past. At a meeting of the Birmingham Gun Trade, it was unanimously decided to demand from the Board of Trade that the import restrictions in so far as they concern the trade should remain in force. It will take at least twelve months for the trade to fully re-establish itself on pre-war basis, and in the meantime it is urged that for a period of six months at least, no alteration should be made as to the import question, and at the end of that period the members are perfectly agreeable to reconsider the matter and to discuss the question as to a proper arrangement being made.

THE BUILDING INDUSTRIES CONSULTATIVE BOARD, representing the architects, surveyors, building trades' employers and operatives of the country, was recently formed by the Royal Institute of British Architects to concert measures to relieve the stagnation in the building trade. One of the first evils it has had to deal with is the excessive cost of building, due in part to the uncertain supply and the high prices of building materials. The Board has been in communication with the Ministry of Munitions, and has accordingly passed the following resolutions and forwarded them to the Ministry of Munitions :—(1) That in the opinion of this Board the stocks of bricks and other building material (in excess of actual Government requirements), which are the property of, or are controlled by, the Government, should be sold in the open market with a reasonable margin above cost to cover expenses. (2) That in the opinion of this Board the building industry and its associated trades should now be and remain free of Government control or interference. The Board are unanimously of opinion that the speedy establishment of a free market in building materials will go far to improve the difficult situation which at present exists.

VISCOUNT BURNHAM presided at the fifteenth meeting of the London and South-Eastern Employment Council, held at the Divisional Office of the Employment Department, Ministry of Labour, Norfolk Street, Strand. It was reported that at the request of the Minister of Labour the Council had undertaken an inquiry into the causes operating to prevent the re-absorption into industry of the still very considerable number of demobilised sailors and soldiers and ex-munition workers in receipt of out-of-work donation from the Employment Exchanges. Amongst matters discussed were the provision of facilities for training disabled men and ex-sailors and soldiers who had not learned a skilled trade before enlistment; the Ministry's scheme for the industrial training of women; and the position of private employment agencies. On this last subject the Council held strongly the view that the existence of the national system of Employment Exchanges should render unnecessary the activities of voluntary organisations and fee-charging agencies. The Council noted with satisfaction a continued decline in unemployment, as revealed by the registers of the Employment Exchanges throughout the London and South-Eastern area. Employers can materially assist the objects which the Council has in view by making it their invariable practice to notify all vacancies to their local exchange.

ON September 4 Greenock commemorated the centenary of the death of James Watt, the principal item in the celebrations being a public meeting in the evening, at which addresses were delivered by the Secretary for Scotland and Lord Inchcape. In the afternoon Mr. Munro, Lord Inchcape, and other distinguished guests and prominent citizens were entertained at a civic luncheon, while in the forenoon an exhibition of paintings, portraits, relics and letters relating to Watt was opened in the Watt Monument. In his appreciation of Watt, Lord Inchcape declaimed that his work was the mainspring of the mechanical progress made in the past hundred years. His Lordship dealt with the special need of the present time to develop the industry of the country which Watt by his work had done so much to establish, and urged application to work on the part of those who lived by brain craft, as well as those who lived by manual labour. To those in authority who preached economy he addressed the maxim that economy, like charity, should begin at home. Lord Inchcape concluded with an appeal to the young men of Greenock to follow the example of Watt in patient industry and determination. The Secretary for Scotland summarised the qualities of Watt as industry, thrift, modesty, justice and vision, and added that these were the qualities which were required to-day for the salvation of a world which was still reeling under the shock of war.

At the recent London conference of Engineering and Shipbuilding Employers' Federation, the Federation of Engineering and Shipbuilding Trades (Employees) and the Amalgamated Society of Engineers, an agreement was reached regarding the question of hours in the shipbuilding and engineering trades. The conference lasted over six hours, and at the conclusion the following official statement was issued on behalf of both sides :—"After discussion it was mutually agreed to recommend to the constituent bodies :—(1) That the working conditions on a 47-hour week should be adjusted with the least possible delay. (2) That a joint committee representative of the employers and the unions' Negotiating Committee be appointed to investigate the economic relations of production to hours of work, and in this connection the methods of manufacture in the shipbuilding and engineering industries in this and other countries. (3) That in the meantime the application for a reduction of hours to 44 per week is adjourned. (4) That the chairman of the Joint Investigation Committee shall be a member of the Committee and alternatively a representative of the employers' and a representative of the unions' Negotiating Committee." The statement was signed for the Engineering Employers' Federation by Sir Alan M. Smith, for the Shipbuilding and Ship-repairing Employers' Federation by Mr. George Carter, and for the Negotiating Committee by Mr. J. T. Brownlie as well as the respective union secretaries.

Much work has been done in recovering a small proportion of the vessels sunk during the war in home waters, but the methods used have been somewhat slow, costly and laborious. Some interesting experiments have recently been carried out on the raising of a ship, the s.s. "Main," which was sunk by gunfire from a German submarine in Luce Bay, in the South of Scotland, during the war. The salvage operations were carried out by the Ardrossan Salvage Company, Glasgow, who undertook to test some flexible pontoons, designed, patented and manufactured by Vickers, Limited, Barrow-in-Furness. The pontoons are made of special canvas and cables, and weigh, when completed, only one ton, yet when inflated with air and submerged in water, are capable of lifting 100 tons. On the trials, two of these 100-ton pontoons were used and fixed to the stern post of the ship and inflated by means of an air compressor on a small tug. The vessel was slowly raised and beached ready for pumping out. The amount of rough handling which these canvas pontoons withstood was remarkable. One advantage is that when not in use they can be packed into a very small compass and stored in the hold of a salvage ship and need only be brought out when actually required. From the information gained during these tests the designers are now confident that pontoons of 200 and 300 tons lifting capacity can be made in the same manner. They are already considering the possibilities of raising the "Lusitania," which would necessitate about 80 of these pontoons of a lifting capacity of 500 tons each.

Orders for locomotives recently placed in this country on behalf of the Indian State Railways include contracts for eighty-two 0-6-0 type to the Vulcan Foundry, Limited, of Newton-le-Willows; seventy 2-8-0 type to Kitson & Company, Limited, Airedale Foundry, Leeds; and twenty-six 4-6-0 type to the Hunslet Engine Company, Limited, of Leeds. The North British Locomotive Company, Limited, have an order for thirty broad-gauge and five metre-gauge locomotives for the Bengal Nagpur Railway. Sir W. G. Armstrong, Whitworth & Company, Limited, are supplying twenty-five 2-8-0 type broad-gauge locomotives to the Bombay, Baroda and Central India Railway and seventeen 2-8-0 type broad-gauge locomotives to the Madras and Southern Mahratta Railway. Nasmyth, Wilson & Company, Limited, of Patricroft, Manchester, have been awarded contracts for seventeen locomotives for the Burma railways, twelve for the Assam-Bengal Railway, ten for the Eastern Bengal State Railway, ten for the South Indian Railway, and nine for the Nizam's Guaranteed State Railway. The Great Indian Peninsula Railway Company have also ordered from the North British Locomotive Company, Limited, 100 locomotives for their broad-gauge lines, comprising thirty 2-10-0 type engines, sixty 2-8-0 type goods engines, and ten 0-8-4 "Ghat" tank locomotives, while the Vulcan Foundry Company, Limited, are to supply four standard passenger engines of the 4-6-0 type.

Extensive reductions are to take place, in the interests of national economy, in the personnel of Portsmouth Dockyard. In answer to a deputation representing all the dockyard towns, headed by the Mayor of Portsmouth, Dr. Macnamara recently stated that it was impossible to provide work sufficient to maintain the present staff, as not only was there to be no more new construction, but repairs of warships, which had got greatly into arrears, had now nearly been completed. It has been rumoured that the Admiralty intended sending merchant ships, taken over for purposes of the war, to the Royal dockyard for reconditioning to their ordinary trade duties. That would provide a large amount of work, and prevent immediate discharges, but up to the present no information had been received at the office of the Admiral-Superintendent at Portsmouth of the prospect of any such ships coming. Prior to the war the total strength of workmen at Portsmouth Dockyard was about 12,000. During the war it was increased to close on 24,000. The coming reduction is expected to be to pre-war strength. The latest figures from the local Employment Exchange show that of the men unemployed at Portsmouth about 80 per cent. are discharged soldiers. With a view to finding these work, a deputation from the Demobilised Soldiers' and Sailors' Association waited upon Dr. Macnamara, who promised that women having no dependents on them should be discharged from Admiralty establishments, and their places taken by demobilised Service men. This promise is now being carried out, and a great many women have recently been discharged, and ex-Service men taken on in their places.

Personal.

The late Mr. W. Holehouse, engineer, of Moor Dene, Bramhope, Leeds, left £8,461.

The late Mr. W. R. Corfield, a director of Hill's Dry Dock and Engineering Company, Limited, left £17,554.

Mr. Charles Alfred Mather, of Heathcote, Bootle, Lancashire, iron merchant, has left estate of the value of £60,241.

Sir Glynn West has recently been appointed vice-chairman of Sir W. G. Armstrong-Whitworth & Company, Limited.

Mr. J. S. Hollings (Brymbo Steel Company, Limited) has been appointed a magistrate for the County of Denbigh.

The gross value of the estate of the late Mr. J. B. Habershon, steel manufacturer, of Holmsfield, Kimberworth, Rotherham, is £25,687.

Mr. W. J. Hands, O.B.E., has been appointed by the President of the Board of Trade to be Controller of the Profiteering Act Department.

Mr. E. Marchant Jenkins, accountant at Vivian's copper works, Port Talbot, has started in business at Port Talbot as an iron, steel and metal merchant.

Mr. John Petrie Robertson, engineer and ironfounder, Dundee, who resided at Eastbrook, Newport, Fife, left estate of the gross value of £31,403.

Mr. Arthur Richards, J.P., director of Richards & Sons, Darlaston, has been appointed a director of the Liberty Shipbuilding and Dry Dock Company.

The Minister of Munitions has approved the appointment of Lieutenant-Colonel R. L. Corbett as

Deputy to the Director-General of Stores and Transport.

MAJOR MORRISON, who won the Air Force Cross and the Croix de Guerre, has been the recipient of a presentation from the Radcliffe and Hauxley Soldiers' and Sailors' Fund.

MR. GEO. AINSWORTH, of the Consett Iron Company, Limited, was recently presented with four handsome silver salvers from the works officials on his retirement from the post of general manager of the firm.

SIR BENJAMIN JOHNSON has tendered his resignation as Director-General of Factories, and the Minister of Munitions has accepted it with great regret. The Minister has appointed Mr. E. C. Given to succeed him.

MR. ANDREW HETHERINGTON, a member of the staff of Messrs. Workman, Clark & Company, Limited, was recently presented with a gold watch and roll-top desk on the occasion of his leaving the firm after 23 years' service.

THE late Mr. S. L. Dore, J.P., senior partner in Brooke, Dore & Company, metal merchants, 5, Fenchurch Street, E.C., and managing director of Baldwins, Limited, left estate of the value of £205,731, the net personalty being £153,374.

MESSRS. J. F. CARR and T. T. D. Geesin, electrical and mechanical engineers, 1, Montague Street, Russell Square, London, W.C., trading under the style of Carr, Geesin & Company, have dissolved partnership. MR. Geesin continues on his own account.

MR. G. J. ALLAN has been appointed to succeed Mr. A. Gulston as superintendent engineer at the Walker yard of Sir W. G. Armstrong, Whitworth & Company, Limited. Mr. Allan has been with the Walker firm during the last 23 years, part of that time acting as assistant to Mr. Gulston.

SIR RICHARD GLAZEBROOK has resigned the directorship of the National Physical Laboratory, Teddington, which he has held since its inception in 1899. He is succeeded by Professor Petavel, Professor of Engineering and Director of the Whitworth Laboratory in the University of Manchester.

MR. A. B. SWEET-ESCOTT, for 15 years manager of Messrs. C. H. Bailey's Tyne Engine Works, Newport, who has now severed his connection with the firm, upon receiving an appointment with the Ebbw Vale Steel, Iron & Coal Company, Limited, has been the recipient of a presentation from the officials and men.

SIR GEORGE CARTER, managing director of Cammell, Laird & Company, Limited, Birkenhead, who has been Chairman of the Shipbuilding Employers' Federation during the war, has been entertained to dinner in recognition of his services to the industry. Mr. W. H. Dugdale, vice-president of the Federation, presided.

SIR ERNEST MOIR, in recognition of his services during the war, has had the rank of Officer of the Legion of Honour conferred on him by the French Government. Early in the war Sir Ernest reported for Mr. Lloyd George on shell production in France, and afterwards was one of the founders of the Advisory Committee of the Ministry of Munitions.

MR. THOMAS BURT, of Newcastle, the veteran miners' leader, has received numerous congratulations as one of the legatees of £1,000 a year under Mr. Carnegie's will. Mr. Burt once defended Mr. Carnegie against several aspersions of Mr. Keir Hardie on conditions at Pittsburgh, and this was the beginning of the friendship between Messrs. Carnegie and Burt.

MR. MATTHEW PLETTS, who took a leading part in the nine-hours' strike in the engineering and other trades in the year 1871, has lately retired into private life. Mr. Pletts carried on business for some years in Scotswood Road, Newcastle, and afterwards became an official with an engineering firm in London. He has been connected with these engineering works for many years, and has now resigned, on pension.

OWING to the resignation of the secretary, Mr. John Hall, in consequence of pressure of business, the committee of the Scrap Iron, Steel, Metals and Machinery Merchants' Association (North-Western Area) have appointed Mr. H. H. Baron, of the firm of J. Needham & Company, Parr's Bank Buildings, 3, York Street, Manchester, as secretary to the Association. The offices of the Association are now at Parr's Bank Buildings.

MR. W. H. DUGDALE, of Sunderland, has been elected president of the Shipbuilding Employers' Federation. He is, in addition, chairman of the Wear Shipbuilding Association, managing director of S. P. Austin & Son, Ltd., a past president of the North-East Coast Institution of Engineers and Shipbuilders, a past president of the Sunderland Chamber of Commerce, chairman of Lloyd's Technical Sub-committee, chairman of the Works Committee of the River Wear Commissioners, and a member of the Institute of Naval Architects.

THE RIGHT HON. JOHN HODGE, M.P., presided over a dinner given in London in honour of Mr. James Cox, J.P., of Darlington, and for 21 years secretary of the Associated Iron and Steel Workers' Society. During the evening Mr. Jabez Hall, the last president of the Associated Iron and Steel Workers' Society before its amalgamation with the Confederation, presented the Iron and Steel Trades' Confederation with a bust of Mr. James Cox, J.P., and also a bronze tablet containing the names of the first and last executives of the British Steel Smelters, Mill, Iron, Tinplate and Kindred Trades' Association.

CAPT. W. HEDLEY GRAHAM has been appointed general manager of the Tyne Engine and Ship Repairing Works, Newport and Barry, of the Cardiff Junction Dry Dock Company, Limited, and the Tubal Cain Foundry and Engineering Works, Cardiff. Mr. J. P. Galletly has been appointed manager of the Cardiff Junction Dry Dock Company, Cardiff and of the branch works at Barry, and also of the Tubal Cain Foundry at Cardiff. Mr. L. T. G. Soulsby has been appointed manager of the Tyne Engine and Ship Repairing Works, Newport. Mr. M. Roberts has been appointed works' manager of the Tyne Engineering and Ship Repairing Works at Barry.

MR. R. W. VICK, J.P. (one of the original directors), and Mr. D. Cooke have retired from the board of Furness, Withy & Company, Limited. These vacancies have been filled by the election of Mr. S. J. Forster, the secretary, and Mr. R. I. Dodsworth, head of the London office steamship management department, as directors. As we previously briefly announced, Viscount Furness has decided to relinquish the chairmanship of the company and devote himself more particularly to shipbuilding, steel and coal interests. Mr. W. Furness, Mr. E. Furness and Mr. C. E. Furness are to be associated with him in these enterprises and have also retired from the board. Sir Frederick W. Lewis, Bart., has been elected to the chairmanship of the board, and the four vacancies have been filled by the election of Sir John Esplen, Mr. F. H. Houlder, Mr. W. C. Warwick, and Mr. N. Douglas as directors. Mr. E. A. B. Forster has been appointed the secretary of the company.

NATIONAL HEALTH WEEK.—We understand that it has been decided to hold the first post-war National Health Week in May, 1920. Previous to the war, the celebrations in connection with this week, both in the Metropolis and in the various local centres throughout the kingdom, served to focus public opinion and sentiment on those aspects of personal and public hygiene which are more directly the province of the man in the street and the woman in the home than of the medical and sanitary authorities. We think it is not making too great a claim to state that the pioneer work done by the Health Week Committee was one of many like factors in establishing the need for the newly-formed Ministry of Health.

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Pneumatic, Hydraulic, Jar Ramming, & Hand Power.

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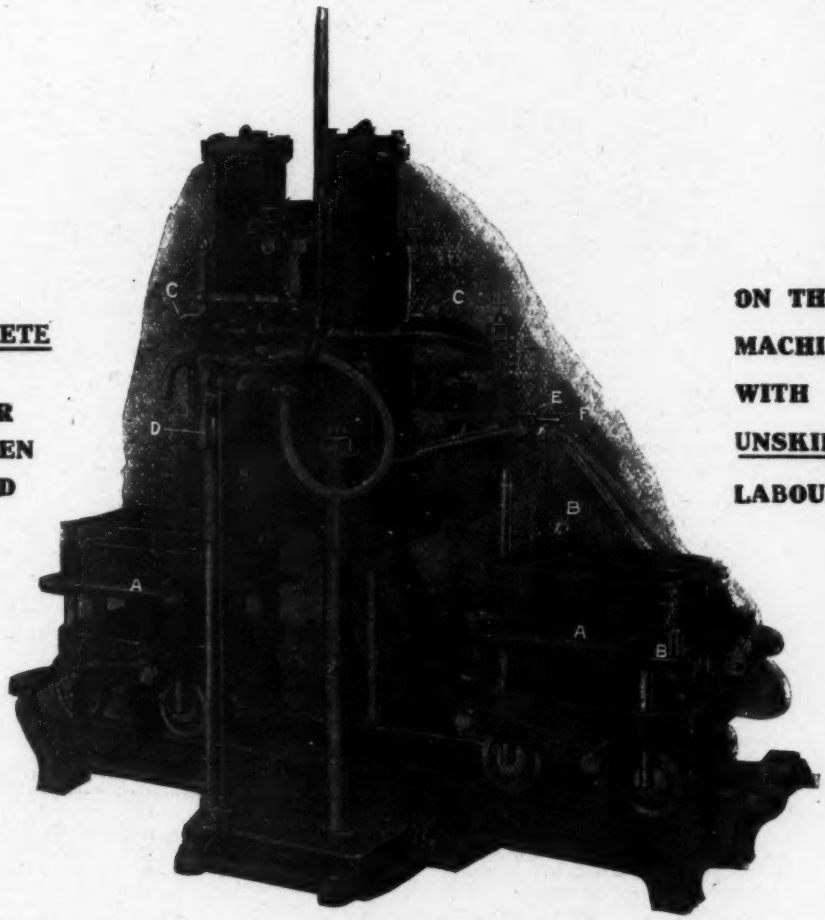
Fitted with self-adjusting Rammer Head which accommodates itself to any varying depth of pattern.

OVER 50 COMPLETE MOULDS PER HOUR HAVE BEEN PRODUCED



ON THIS MACHINE WITH UNSKILLED LABOUR.

One of many that we have installed in various Munition Work Centres.

JAMES EVANS & CO., BRITANNIA WORKS, BLACKFRIARS, MANCHESTER.

Applications for Patents.

Akt.-Ges. Brown, Boveri, et Cie. Lids for melting-furnaces and crucibles. 21,569. September 2 (Switzerland, September 14, '18.)

Armstrong, Whitworth & Company, Sir W. G. Keyless locks. 19,089. August 1.

Ballentine, J. H. Nut-locks. 18,822. July 29.

Ballantyne, W. B. Production of chrome iron or chrome steel alloys. 20,201. August 16.

Basset, L. P. Revolving furnace for direct production of iron or steel, etc. 21,677. September 3. (France, September 3, '18.)

Bird, F. H. Manufacture of cast-metal bars, rods, and strips. 21,951. September 6.

Bloom, A. Appliances for casting metal ingots in groups or clusters. 21,117. August 28.

Boever, A. Manufacture of brass and alloys of copper. 22,296. September 10. (Switzerland, September 11, '18.)

Bower, C. O. Furnace blast tuyeres. 18,792. July 29.

British Thomson-Houston Company (*General Electric Company*). Electric welding apparatus. 21,656. September 3

Broady, W. Machine for contracting and expanding sheet metal, tubes, etc. 21,847. September 5.

Browning, W. J. Process for extraction of metals from minerals or solutions or for separation or refinement of metals. 19,028. July 31.

Burtingham, H. A. Cylinders for internal-combustion engines. 22,050. September 8.

Bygloverza, Limited, and Ormes, S. Production of iron. 19,139. August 2.

Coles, S. O. Cowper-. Process for building up or growing iron upon steel, etc., surface. 19,427. August 6.

Coles, S. O. Cowper-. Manufacture of iron tubes by electro-deposition. 19,429. August 6.

Coles, S. O. Cowper-. Process for recovery of iron from scrap tinned steel. 19,431. August 6.

Coles, S. O. Cowper-. Process for production of spring or tempered copper. 22,376. September 11.

Coles, S. O. Cowper-. Process for manufacture of zinc cylinders for primary batteries. 22,377. September 11.

Coles, S. O. Cowper-. Process for converting blue billy into high-grade iron. 22,596. September 13.

Cotton, F. Furnaces for burning low-grade fuel. 22,444. September 12.

Cromwell, J. C. Forging apparatus. 18,915. July 30.

Davison, G. Casting copper seamless boilers. 19,196. August 5.

Davy Bros., and Hand, T. W. Tyre slabbing and punching presses. 18,994. July 31.

Dutoit, P. Manufacture of brass and alloys of copper. 22,296. September 10. (Switzerland, September 11, '18.)

Essex, S. Tools for turning, screw-thread cutting, etc. 19,218. August 5.

Expanded Metal Company, Booton, H., and Salmon, H. Machines for expanding metal. 22,291. September 10.

Gibbs, A. Stoves, ovens, etc., for drying or heating tinplates, etc. 19,154. August 2.

Griffiths, H., and H. A. Griffiths. Sheet-metal-working machines. 20,955. August 26.

Hamer, W. Dampers for furnaces, etc. 20,514. August 21.

Haslam, A., and Morris, H., Limited. Machinery for charging blast furnaces. 19,126. August 2.

Hatfield, W. H. Portable spring-actuated devices for testing hardness of metals. 20,617. August 22.

Herge, H. G. Steel sheet piling. 21,989. September 6

Houldsworth, J. W. Means for extracting particles, etc., of iron or steel from ores, mixtures, etc. 22,072. September 3

Hurst, J. E. Manufacture of moulds for centrifugal casting-machines. 22,602. September 13.

Imbery, A. Electric furnaces for continuous heating of rivets, etc. 20,518. August 21.

Jones, F. G. Methods for producing malleable iron castings. 20,521. August 21.

Leach, F. R. Fans for cooling, heating, ventilating, etc. 20,268. August 18.

Lloyd, H. D., Wilson, W. W., and the Whitecross Company. Electrodes for welding, etc. 19,083. August 1.

Marriott, W. Metal reinforcements of reinforced-concrete constructions. 21,473. September 1.

McConnell, J. Processes of manufacturing electric steel. 18,868. July 30.

Metals Extraction Corporation. Electrolytic cells for deposition of metal from solution. 22,541. September 13.

Newman, T. F. Process for protecting ferrous metals from rust. 20,656. August 22.

Parmiter. R. P. Appliance for bending steel rods. 20,622. August 22.

Richman, P. R. Device for clamping metals to face-plate, etc., of milling, etc., machines. 20,383. August 19.

Rogers, F. Rolling or forging metals. 19,066. August 1.

Ryan, W. Tool for taking down or shouldering iron, etc., rods. 22,192. September 9.

Schofield, J. P. Machine tools. 21,872. September 5.

Stokes, F. W. Manufacture of moulds for centrifugal casting-machines. 22,602. September 13.

Wickett, J. H. Process for treating castings of ferrous metals. 21,691. September 3.

Deaths.

THE death is announced, at the age of 65, of Mr. W. S. Procter, of Headingley, Leeds. Mr. Procter was secretary of the Yorkshire Iron and Coal Company, Limited, in which company he had been employed from the age of 14.

MR. J. PARKES died at his residence, Woodside, Shrewsbury Road, Dublin, on September 7. He was chairman and managing director of John C. Parkes & Sons, Limited, iron, tinplate, and metal merchants and agents, 110, Coombe, Dublin.

THE death has taken place at Brynonen, Pant, Dowlais, of Mr. Thomas Benjamin Hirst, for 29 years steel-furnace manager at Messrs. Guest, Keen & Nettlefolds' works, and subsequently works manager of the Blaenavon works for seven years, when he retired.

MR. JAMES MUSGRAVE, of Knowsley Grange, Heaton, Bolton, who died in his 81st year on Sunday, September 14, was a member of an old family which had been connected with the engineering industry for the better part of a century. About 25 years ago he retired from the managing directorship of John Musgrave & Sons, Limited, Globe Ironworks, and at the time of his death he was a director of several spinning companies.

WE regret to announce the death of Mr. John Richard Kidston Law, chairman of the firm of William Jacks & Company, Limited, Glasgow. Mr. Law, who was 62 years of age, had what seemed a slight hemorrhage of the brain about three weeks before his death, and it was hoped that he would completely recover; but he became steadily worse, and died at 1.30 a.m. on Friday, August 29. In his early life Mr. Law was a tea planter in Ceylon, but about the year 1890 he became associated in business with the late William Jacks and his brother, Mr. Bonar Law, and on the death of Mr. Jacks (Mr. Bonar Law having retired some time before) he became senior partner of the firm.

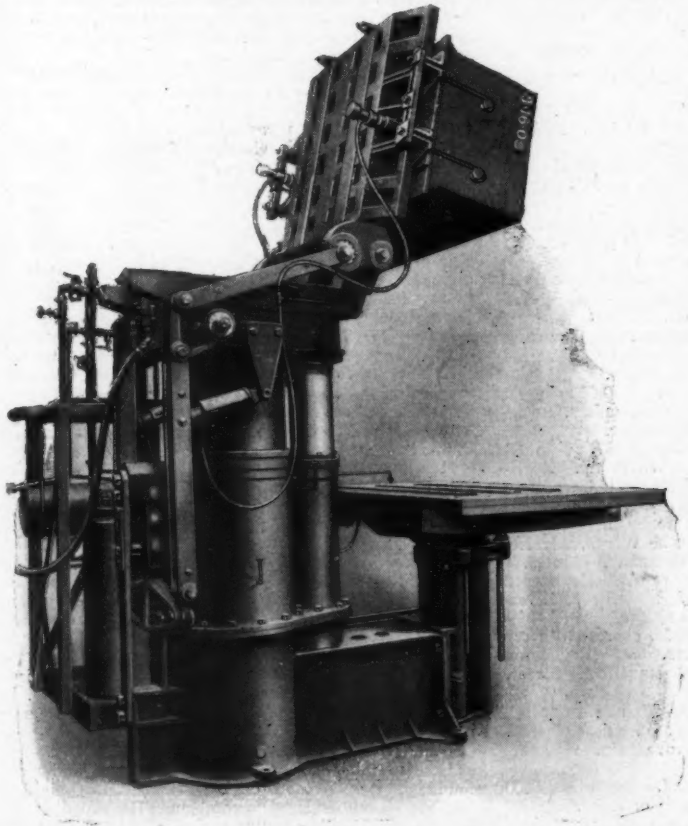
Mr. Law impressed everyone with whom he came in contact as a man of very exceptional intellectual ability. In business circles he was much respected and liked. His chief interest was in scientific subjects, of which he possessed a wide and accurate knowledge.

MACNAB & Co.,

56/8, Eagle Street, Southampton Row, LONDON, W.C.1.

Tabor Combination Shockless Jar Ramming Power Roll-over and Pattern Drawing Moulding Machine.

Suitable for the most economical production of any repetition work from the smallest up to a load of 12,000 lbs. at 100 lbs. air pressure, covered by a range of five machines.



Mould having been rammed, box and pattern in act of being rolled over on to levelling table on other side of machine.

Jar rams the box in less than one minute.

Rolls the mould over, draws and raps the pattern.

Rolls the pattern back ready for the next box.

COMPLETE MECHANICAL OPERATIONS OF THE MACHINE NOT EXCEEDING FOUR MINUTES.

New Companies.

Vickers-Hellenic, Limited, steel manufacturers, etc.—£10,000 in £1 shares.

American Machine and Foundry Company, Limited.—Capital £50,000 in £1 shares.

Pickard, Dobson & Company, Limited, Engineers.—Capital £20,000 in £1 shares.

Lemco, Limited.—Capital £7,000 in £1 shares, to carry on the business of electricians.

Silica Products, Limited.—Capital £25,000 in £1 shares. Registered office: 482, Attercliffe Road, Sheffield.

Cravens, Limited.—Capital £10,000 in £1 shares, to carry on the business of railway construction contractors, etc.

Vickers-China, Limited.—Capital £10,000 in £1 shares. Registered office: Vickers House, Broadway, Westminster, S.W.

Eastern Engineering & Supply Company, Limited.—Capital £5,000 in £1 shares. Registered office: 351, High Street, Stratford, E.15.

Engineering Products Company, Limited. — Capital £10,000 in £1 shares (6,500 preference). Registered office: 61, Holborn Viaduct, E.C.

Brassfoundry Machine Tool Company, Limited.—Capital £5,000 in £1 shares. Registered office: 262, Corporation Street, Birmingham.

Commercial Welding and Engineering Company, Limited.—Capital £5,000 in £1 shares. Registered office: 7, Dumfries Place, Cardiff.

Charles Benn & Sons, Limited.—Capital £20,000 in £1 shares, to carry on business as boilermakers. Registered office: 10, Park Row, Leeds.

J. R. Chance, Limited.—Capital £1,500 in £1 shares, to carry on business as engineers, etc. Registered office: 27, Cato Street North, Birmingham.

Burt Brothers, Limited.—Capital £50,000 in £1 shares (25,000 7½ per cent. cumulative preference), to carry on the business of coppersmiths.

Darling & Lloyd, Limited, Engineers.—August 20, £10,000 in £1 shares (3,000 preference). Victoria Works, Victoria Road, Oswestry, Salop.

Unicorn Engineering Company, Limited.—Capital £12,000 in £1 shares (2,400 founder'). Registered office: 19, Eldon Park, S. Norwood, S.E.

Delta Electrical & General Engineering Company, Limited.—Capital £1,000 (£5). (Private.) Registered office: Kilnholm Mills, Stacksteads, Bacup.

Poyser's Patents, Limited.—Capital £20,000 in £1 shares, to carry on the business of ironfounders. Registered office: 52, Brown Street, Manchester.

Royles (Altrincham), Limited.—Capital £7,000 in £1 shares, to carry on the business of engineers. Registered office: 72, Oakfield Road, Altrincham, Ches.

John Spence & Sons (Airdrie), Limited.—Capital £10,000 in £1 shares, to carry on the business of brass founders. Registered office: Belladyke Works, Airdrie.

Patent Metallic Manufacturing Company, Limited.—Capital £5,000 in £1 shares (2,000 pref.). Registered offices: 6, Radcliffe Buildings, 37, Moorfields, Liverpool.

Patex, Limited.—Capital £100 in 1s. shares, to carry on the business of patent experts, etc. Registered office: Albert Buildings, 151-7, Fitzwilliam Street, Sheffield.

James N. Durie & Company, Limited.—Capital, £10,000 in £1 shares, to carry on the business of engineers. Registered office:—28, Grove House Lane, Leeds.

Thomas Crompton & Sons, Limited.—Capital £40,000 in £1 shares, to carry on the business of lock manufacturers, etc. Registered office: 41, Gerard Street, Ashton-in-Makerfield.

Clyno Engineering Company, Limited. — Capital £120,000 in £1 shares, to take over the business carried on at Wolverhampton by F. Smith as the Clyno Engineering Company.

Walter Somers (1919), Limited.—Capital £375,000, to acquire and carry on the business of manufacturing, forging, filling-up, and finishing every description of iron and steel work.

Harrap Wilkinson, Limited.—Capital £5,000 in £1 shares (4,000 ordinary and 1,000 founders'), to carry on the business of ironfounders. Registered office: Quay Street, Salford.

West Riding Pulley Works, Limited.—Capital £3,000 (£1). Makers of wrought iron and steel pulleys and pulley parts, etc. (Private.) Registered office: Walkley Lane, Heckmondwike.

Monmore Green Rolling Mills Company, Limited. — Capital £24,050 in 24,000 shares of £1 each, and 1,000 deferred shares of 1s. each. Registered office: Monmore Green, Wolverhampton.

T. N. Waldron, Limited.—Capital £2,000 in £1 shares, to take over the business of stampers and piercers, carried on at 211, Newhall Street, Birmingham, as Rawcliffe & Waldron.

Middlesbrough Steel Tube and Conduit Company, Limited.—Capital £15,000 in £1 shares (14,900 ordinary and 100 management). Registered office: Lower Commercial Road, Middlesbrough.

Greenside Foundry Company.—Capital £2,000 in £1 shares, to take over business of iron founder, carried on as the Greenside Foundry Company at the Greenside Foundry, Chapeltown, Yorks.

Pettigrew & Merriman.—Capital £20,500 (£1) (10,000 8 per cent. cumulative preference ordinary and 10,500 ordinary). Mechanical and electrical engineers, instrument makers, etc. (Private.)

Birmingham Phosphorising & Alloy Casting Company.—Capital £10,000 in £1 shares, to carry on the business of smelters, founders, refiners. Registered office: 6, Berkeley Street, Birmingham.

British-Australian Engineering Company, Limited.—Capital £25,000 in £1 shares, to adopt an agreement with H. C. Siddeley and with R. W. Wild. Registered office: Australia House, Strand, W.C.2.

Premier Aluminium Casting Company. — Capital £5,000 in £1 shares, to carry on the business of aluminium casters, manufacturers of motor car, cycle, and aeroplane parts and accessories, etc.

Gay Brothers.—Capital £10,000 in £1 shares. Objects: To carry on the business of die-sinkers, toolmakers, stampers, pressers, piercers, etc. Registered office: Tenby Works, Tenby Street North, Birmingham.

Arthur Greaves (Lees).—£6,000 (£1). To take over the business of sheet metal workers, etc., carried on by A. Greaves, at 82, High Street, Lees, Lancs., as Arthur Greaves. Private. 82, High Street, Lees, near Oldham.

Maritime Engineering and General Repairing Company, Limited.—Capital £2,000 in £1 shares. First directors: A. W. Hertz and A. H. Hertz (both permanent). Registered office: The Docks, Port Talbot, Glamorgan.

Scottish Stamping & Engineering Company, Limited—Capital £100,000 in £1 shares. First directors: Sir Thomas R. Thomson, J. G. Latta, J. G. Young, and W. Lees. Secretary: J. G. Latta. Registered office: Neptune Works, Ayr.

Indented Bar & Concrete Engineering Company, Limited.—Capital £60,000 in £1 shares. First directors: J. T. Petro, R. W. Vawdrey, H. Murray, C. H. Whittington, and L. Mather. Registered office: Queen Anne's Chambers, S.W.1.

Foundrometers, Limited.—Capital £3,000 in £1 shares, to take over the business of brass and metal founders, etc., carried on by Messrs. H. Creighton, W. S. Sixsmith, H. Dowson, and H. Broadbent at 7 and 9, South Brook Street, Leeds.

G. M. Hay & Company, Limited, 86, Arthur Street, Bridgeton, Glasgow (private company), to take over the business of ironfounder and engineer hitherto carried

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Tough, Best Selected and Refined Ingots, Electrolytic Ingot Bars, Wire Bars, and Cathodes.

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All Brands Ingot and Bar Tin.

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ROYAL EXCHANGE, MIDDLESBRO'.

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83, HOPE STREET, GLASGOW.

WILLIAM COLVIN & COMPANY,

MIDDLESBOROUGH AND GLASGOW.

on by G. M. Hay at Strathclyde Foundry at above address. Capital, £30,000 in £1 shares.

Burston, Read, & Company, Limited.—Capital £5,000 in £1 shares. To take over the business of hardware and bolt and nut manufacturers carried on by E. F. Burston and E. Read, at 97, Dudley Road, Wolverhampton, as "Burston, Read, & Company.

Newcastle Shipbuilding Company, Limited.—Capital £100,000 in £1 shares, to take over the business formerly carried on by J. Cross as the Huntley Shipbuilding and Repairing Company, at Hebburn, Durham. First directors: J. Cross and H. H. Doeg.

Empire (Alloy) Steel Corporation, Limited.—Capital £250,000 in £1 shares, to adopt an agreement with W. B. Ballantine and D. C. Lee. First directors: D. C. Lee and Lieut.-Commander W. B. Ballantine. Secretary, H. E. Barwell. Registered office: 62, Pall Mall, S.W.1.

Middlesbrough Steel Tube & Conduit Company, Limited.—Capital £15,000 in £1 shares, to carry on the business of manufacturers of steel and iron tubes of all kinds. First directors: W. H. Mill (chairman), J. Mather, R. W. Perry, and J. Mill. Registered office: Lower Commerical Street, Middlesbrough.

Midland Bolt, Nut and Rivet Company.—Private company, registered August 20. Capital £25,000 in £1 shares. Objects: To carry on the business of manufacturers of and dealers in bolts, nuts and rivets, factors, shippers, importers, engineers, &c. Registered office: Midland Works, Beard Street, Darlaston.

Fairless Engineering Supplies Company, Limited.—Capital £8,000 in £1 shares, to take over the business of engineers carried on by G. P. Fairless and W. T. Hill at Stockton and Thornaby as the Engineering Supplies Company. First directors: G. P. Fairless (managing director) and W. T. Hill.

Buckleys, of Sheffield, Limited.—Capital £100,000 in £1 shares (50,000 preference). To take over the business of Samuel Buckley & Sons, steel manufacturers and merchants, Sheffield. First directors: S. Buckley, 3, Wilkinson Street, Sheffield; H. Shaw, 12, Wilton Place, S.W.1. Registered office: 35, Paradise Street, Sheffield.

Sun Foundry Company.—Capital £5,000 in £1 shares. To acquire the business of the Sun Foundry Company, carried on by C. Ray at 326, Newtown Row, Birmingham, and the foundry plant and effects owned by W. Thompson, of 8, Barnsley Road, Edgbaston, Birmingham. Registered office: 326, Newtown Row, Birmingham.

A1 Screw Company, Limited.—Capital £10,000 in £1 shares. To take over the business of a screw and nut manufacturer carried on by A. H. Smith, at 7, Smallbrook Street, Birmingham, as the "A1 Company," and to carry on the business of manufacturers of screws, rivets, etc. Registered office: 7, Smallbrook Street, Birmingham.

Patent Metallic Manufacturing Company, Limited.—Capital £5,000 in £1 shares (2,000 preference), to take over the business carried on at 16, Borough Road, Seacombe, Cheshire, to carry on the business of export or import machine brokers, ironfounders, etc. First directors: G. T. Swan, F. J. Chell, and A. Whitford. Registered office: 6, Radcliffe Buildings, 37, Moorfield, Liverpool.

Welsh Tinplate & Metal Stamping Company, Limited.—Capital £500,000 in £1 shares, to take over the business of the Welsh Tinplate and Metal Stamping Company, Limited (incorporated in 1911), and to carry on the business of manufacturers of and dealers in iron, steel, terne and black plates, etc. First directors: D. Williams, J. Holmes, T. Jones, Brynmair, Llanelly; and P. Douin, Beuorages, Nord, France. Registered office: Cambrian Works, Sea Side, Llanelly.

Firth-Derihon Stampings, Limited.—Capital £120,000 in £1 shares (60,000 "A" and 60,000 "B"), to take over the business of die makers and metal stampers carried on by U. G. Derihon in Great Britain, and to enter into an agreement with Thos. Firth & Sons, Limited, and U. G. Derihon. First directors: F. C. Fairholme, F. Best, and J. W. Fawcett (nominees of Thos. Firth & Sons, Limited, and holders of "A" shares), and E. Derihon, J. D. Juling, and S. C. S. Hickson (nominees of U. G. Derihon, and holders of "B" shares).

T. E. MANSERGH.

EVERY DESCRIPTION OF
MOULDERS'
PATENT WOOD, MINERAL AND
COAL DUST BLACKINGS
MANUFACTURED.

Wheathill
Charcoal Works, **SALFORD.**

SANKEY

Pressed Steel
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Plain or Lipped

Let us know your requirements and we will quote you.

Joseph Sankey & Sons Ltd
Wellington ~ Shropshire

LEGGE'S IRON CEMENT.

The most efficient for general Engineering and Foundry Work.

It repairs permanently and effectively makes good all defects in Castings, leaking parts and connections in Steam, Water, Gas and Air, etc.

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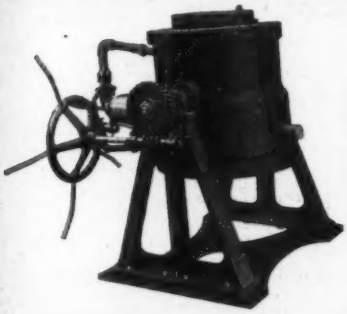

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Melting Furnaces for Brass, Aluminium, Copper, Nickel, Steel, Cast Iron, etc.

1 Gallon of Oil will melt 100 lb. Brass in a Monometer Furnace.

Ask for full particulars:—

MONOMETER MFG. CO., LTD., ASTON, BIRMINGHAM

Dust Fan.

High Pressure Fans.

Volumetric Fan.

Fans for Ventilation, for Dust Removal, for Induced & Forced Draft on Boilers.

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FANS

Cupola and Forge Fire Fans for large or small duties. Reliable and efficient.

Davidson & Co., Limited.,

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FIRE CLAY.

Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

J. GRAYSON LOWOOD & Co., Ltd.,

DEEPCAR nr. SHEFFIELD.

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MONTHLY PRICE LIST.

The undermentioned prices unless otherwise specified, are those obtaining at the commencement of the current month.

Pig-Iron.

	Home £ s. d.
Hematite—	
East Coast Mixed Nos.	10 0 0
East Coast No. 1	10 2 6
West Coast Mixed Nos.	10 4 6
Scottish Mixed Nos.	10 10 0
Welsh Mixed Nos	10 10 0
Cleveland—	
No. 1	8 4 0
No. 3 foundry G.M.B.	8 0 0
No. 4 foundry	8 0 0
No. 4 forge	8 0 0
Basic	8 5 0
Derbyshire, Leicas., and Notts—	
No. 4 forge	8 15 0
No. 3 foundry	9 0 0
No. 2 foundry	9 2 0
No. 1 foundry	9 4 0
Basic	9 2 6
Northamptonshire—	
No. 4 forge	8 7 6
No. 4 foundry	8 9 0
No. 3 foundry	8 10 0
No. 2 foundry	8 11 6
No. 1 foundry	8 13 6
Basic	8 17 6
South Staffordshire, Shropshire and Worcestershire—	
Part-mine forge	8 17 6
Part-mine foundry	9 0 0
Common Staffs.	8 7 6
All-mine forge	9 12 6
All-mine foundry	9 17 6
Warm-air forge	11 0 0
Warm-air foundry	11 10 0
Cold blast	14 0 0
Basic	9 2 6
Scottish—	
Foundry	9 15 0

NOTE.—The above prices are those fixed by the makers as a minimum for early delivery. In consequence of works being booked to capacity, makers are not committing themselves for later delivery.

Delivered in Manchester—	
*Derbyshire, No. 3	9 12 6
*Cleveland, No. 3	9 15 0
*Scottish, No. 3	10 5 0

* Merchant prices.

Delivered in Sheffield—	
East Coast hematite	10 7 6
Derbyshire basic	9 12 6
Lincolnshire basic	9 15 0
Do. No. 3 foundry	9 2 6
Do. forge	8 15 0

High-Speed Tool Steel.

	s. d
Finished bars, 14 per cent. Tungsten	2 11
Finished bars, 18 per cent. Tungsten. Per lb. delivered buyers' works.	3 6
Extras—	
Rounds and squares 3 in. to 8 in. inclusive	4d. per lb.
Rounds and squares under ½ in. to ¼ in.	3d. ,,
Flats under 1 in. by ¾ in. to ½ in. by ¼ in., and all sizes over four times 3 in width and over thickness	3d. ,,
Bevels of approved sizes and sections	6d. ,,
If in Coils	3d. ,,
Packing	4s. per cwt
Bars cut to length	10% extra

Scrap from High-Speed Tool Steel—
Scrap pieces, 5d.
Turnings and Swarf, 3d.
Per lb. net, d/d steel-makers' works.

Ferro-Alloys.

Ferro-Titanium—23/25% Ti. carbonless, 1/5.
Ferro-Tungsten.—75/80%, 2/10½.
Ferro-Molybdenum.—70/80%, Mo., 9/6.
Ferro-Vanadium.—35/40%, Va., 25/-.
Metallic-Manganese.—98/99%, carbonless, 3/9.
(All per lb.).
Ferro-Phosphorus.—20/25%, P.
Ferro-Chrome.—4/6%, car., £45 0 0.
Ferro-Chrome.—6/8%, car., £48 0 0.
Ferro-Chrome.—8/10%, car., £48 0 0.
Ferro-Chrome—Specially refined, basis 60% chr., max. 2% car., £108 0 0.
Ferro-Silicon.—45/50% Si., £19 10 0 d/d. at Sheffield Steelworks.
Ferro-Manganese.—80%, £25 loose, £25 0 0 packed. Export £23, according to destination.
(All per ton.).

Copper.

	£ s. d.	£ s. d.
Standard cash	100 5 0	100 10 0
Three months	100 10 0	100 15 0
Electrolytic	110 0 0	121 0 0
Tough	109 0 0	110 0 0
Best selected	109 0 0	110 0 0
Sheets	146 0 0	—
India	145 0 0	146 0 0
American electrolytic spot	118 0 0	—
Do. Aug.-Sept.	116 0 0	117 0 0
Official average price cash, Aug.		97 11 4½
Do. Three months, Aug.		98 11 0
Do. Settlement, Aug.		97 11 0
Do. Electro, Aug.		113 4 0
Do. B.S., Aug.		108 16 8
Average spot price, copper, Aug.		97 10 0
Do. Electro, Aug.		107 10 0

Tin.

	£ s. d.	£ s. d.
Cash	277 0 0	277 10 0
Three months	274 15 0	275 0 0
English	274 0 0	—
Bars	276 0 0	—
Refined	—	—
Straits	277 0 0	—
Australian		277 0 0
Eastern		283 5 0
Banca		277 0 0
Official average price, cash, Aug.		271 8 0
Do. Three months, Aug.		265 7 0½
Do. Settlement, Aug.		271 5 6
Average spot price, Aug.		271 3 0

Spelter.

	£ s. d.	£ s. d.
Ordinary	41 10 0	—
Remelted	38 0 0	39 0 0
Hard	28 0 0	30 0 0
Electro 99.9	45 0 0	45 10 0
English	44 0 0	44 10 0
India	43 0 0	44 0 0
Zinc dust	65 0 0	70 0 0
Do. English	—	—
Zinc ashes, per cent. 70%	12 0 0	13 0 0
Official average price, Aug.		39 16 9
Average spot price, Aug.		39 16 6

Lead.

	£ s. d.	£ s. d.
Soft foreign (nat)		25 12 6
English		26 15 0
Official average price, Aug.		25 1 6¾
Average spot price, Aug.		24 15 0

Antimony.

	£ s. d.	£ s. d.
English regulus		45 0 0
Chinese	43 0 0	to 44 0 0
Crude		38 10 0
Ore		Nominal.

Aluminium.

	£ s. d.
Virgin Metal 98/99—per ton.	150 0 0

Phosphor Bronze.

INGOTS.	Per ton.
Alloy No. I. or II.	—
III., IV., or V.	—
IV. or VII	—
VIII.	—
XI.	—
Cast Strips and Ingots	—
CASTINGS.	Per lb.
I. or II.	—
III., IV. or V.	—
IV. or VII.	—
VIII.	—
XI.	—
No. VII., Chill, Cast, Solid	—
,, Cored Bars	—

Delivery 2 Cwt. free to any town.
10 per cent. Phosphor Copper price of best selected copper. .. £50 above
15 per cent. Phosphor Copper price B.S. .. £70 above
Phosphor Tin (5 per cent.) .. £90 above price of English Ingots.
Phosphor-bronze prices supplied by CHARLES CLIFFORD AND SON, LIMITED, FARFIELD STREET MILLS, BIRMINGHAM.

***Chromium (Metallic).**

98/99— purity, per lb. 6/6	— —

***Nickel.**

In cubes, 98/99— purity per ton	£205 0 0

Nickel Silver.

	per lb.
Ingots for raising	—
Ingots for Spoons and Forks	—
,, rolled to spoon size	—

***Tungsten Metal Powder.**

	per lb.
98/99— purity	3/4

***Molybdenum Metal.**

96/98— purity, per lb	—

***Cobalt Metal.**

	£ s. d.
97— purity, per lb.	0 11

Quicksilver.

75 lb. bottle	23 10

* Net, delivered Sheffield Works.

Scrap Iron and Steel.

Cleveland.	s. d.	s. d.
Steel scrap, heavy melting	—	—
Iron scrap cast (cupola metal)	—	—
(London f.o.b.).		
Heavy steel		120
Light ,,		80
Heavy cast		110

Steel Scrap.

Without Analysis—	Per ton £ s. d.
Heavy steel melting scrap	6 15
Steel planings, turnings and borings	4 15
Steel planings, turnings and borings mixed with wrought-iron or other material	4 0
Other classes of steel scrap, whether or not mixed	6 5
F.o.r. or in barge at nearest siding or wharf.	
With Analysis—	
Heavy steel melting scrap not over 0.04 per cent. p. and s.	7 10
Heavy steel melting scrap not over 0.05 per cent. p. and s.	7 5

Wrought-Iron Scrap.

	£ s. d.
(1) (a) W.I. plates and sections, not less than ¼ in. thick, reasonably clear of rivets, flanged ends, etc., suitable for shearing: cable scrap and chain scrap not less than ½ in. dia.	7 17
(b) Heavy W.I. scrap not less than ¼ in. thick including horseshoes, rivets and bolts, and scrap therefrom	7 17
(c) W.I. scrap under ¼ in. thick, and all W.I. scrap not included in classes 1, 2 and 3	7 17
(2) Mixed W.I. scrap	6 7
(3) Wrought-iron planings, turnings and borings mixed with steel or other materials	4 2
(4) W.I. planings, turnings and borings	4 17

Cast-Iron Scrap.

	£ s. d.
Heavy ord., broken, between 1½ cwt. and 10 cwt. each	6 15
Heavy machinery, broken between 1½ cwt. and 10 cwt. each	7 0
Cold blast, broken, between 1½ cwt., and 10 cwt.	8 15
Ingot mould, unbroken	8 0
Do. broken, between 5 cwt. and 2 tons each	8 5
Do. between 1½ cwt. and 5 cwt. each	8 10
Railway chairs, whole or broken for remelting	7 0
Heavy lumps, not exceeding 2 tons each	6 12
Light	6 5
Burnt, broken ready for cupola	5 10
Burnt fire bars	6 0
Turnings and borings, for iron and steel makers	5 5

Old Metal.

London—	£ s. d.
Copper (clean)	87 10
Brass (clean)	52 0
Lead (less usual draft)	21 10
Tea lead	20 0
Zinc	24 0
New aluminium cuttings	95 0
Brazierv copper	72 0
Gunmetal	72 0
Hollow pewter	180 0
Shaped black pewter	120 0

(Above all d/d merchant's yard).

Metallurgical Coke.

Durham and Northumberland—	£ s. d.
Blast furnace	2 8
Foundry	2 13
Lancs., Staffs., Yorks, Notts., Derbyshire, Lincolnshire and Midland Counties—	
Blast furnace	2 10
Foundry	3 6

F.o.t. at ovens.

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COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

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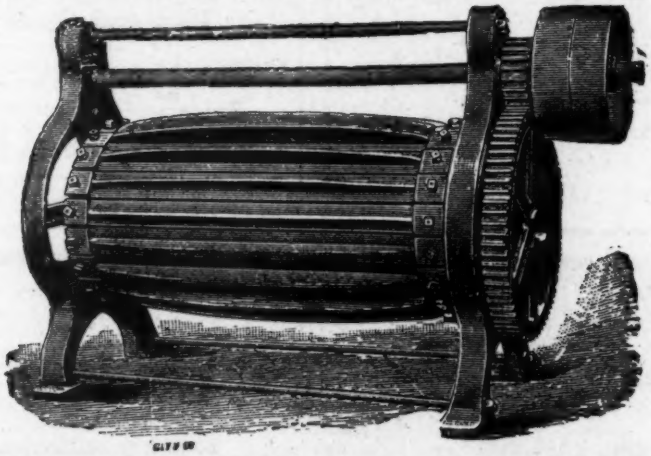

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FOUNDRY CLERK (31) desires change. Thorough knowledge of all clerical work essential in an Iron Foundry. Fifteen years' experience. Wages, costing, etc.—Apply, Box No. 306, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, Adelphi, Strand, London, W.C.2.

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PATTERN-MAKERS.—Wanted, two or three first-class pattern-makers, accustomed to small work.—Apply, Box No. 278, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, Adelphi, Strand, London, W.C.2.

WANTED, three Iron Moulders for Monmouthshire, used to general work.—Apply by letter, stating experience, to Box 310, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, Adelphi, Strand, London, W.C.2.

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WANTED, to Purchase small Roots Blower.—Particulars to T. HOLLEY & COMPANY, 32, Gascoigne Road, Barking.

WHEEL TOOTH MOULDING MACHINE, to take boxes 4 ft. dia. x 2 ft. 6 in. under arm, with change wheels complete, balanced mould holder and 40 wheels. 3 Gas Blowing Rotary Fans, coupled direct to steam engine with cylinder about 3½ in. dia. x 5 in. stroke.—Box No. 290, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, Adelphi, Strand, London, W.C.2.

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500 TONS SMALL AGRICULTURAL MACHINE CASTINGS.

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Ref. D., E. H. BENTALL & CO., LTD., Heybridge, Maldon, Essex.

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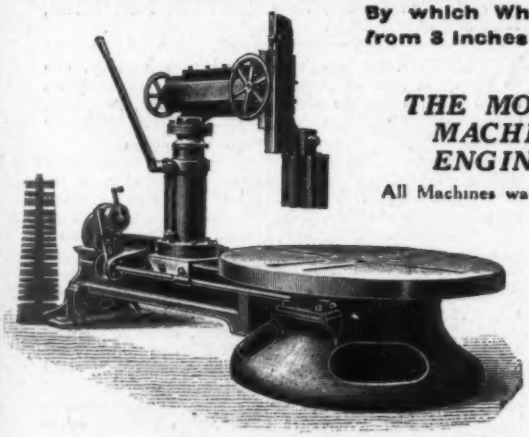

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